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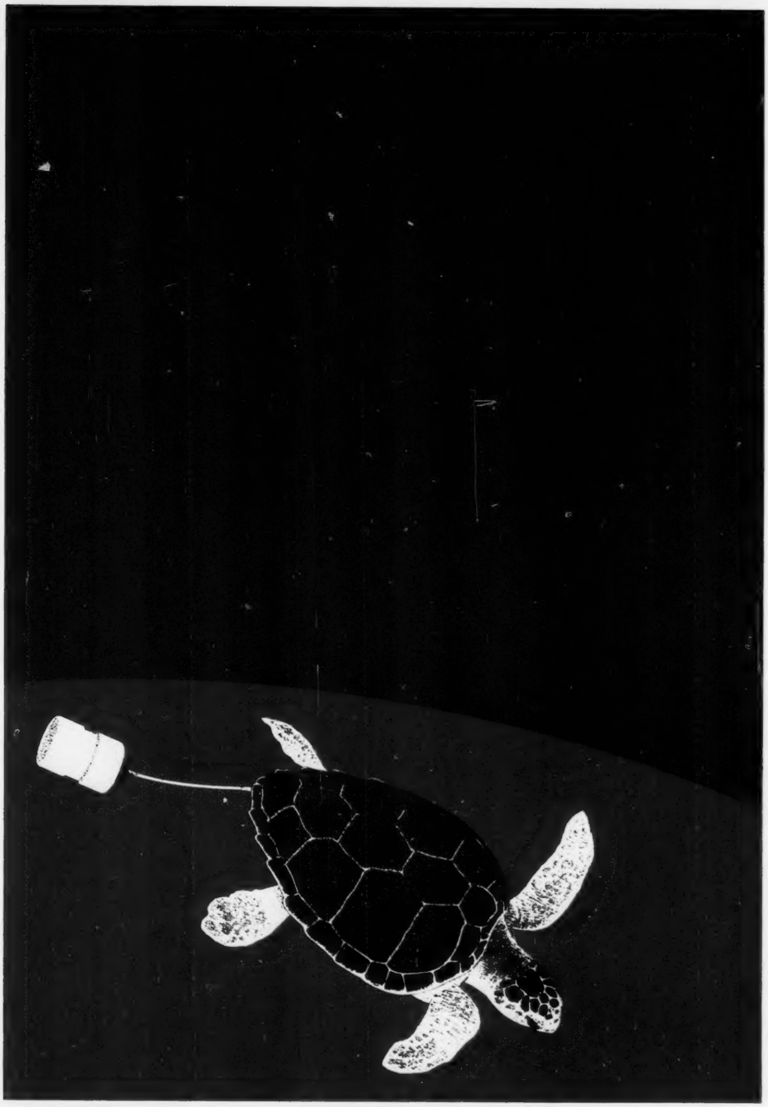
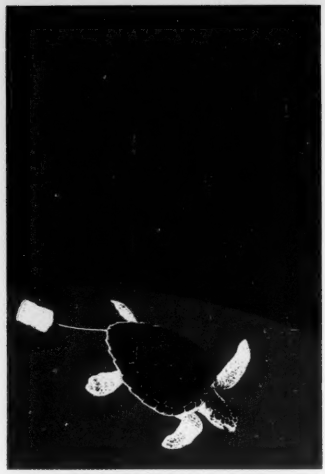


Tracking Sea Turtles by Satellite

Marine Fisheries
REVIEW



On the cover: The sea turtle tracking design by Harold L. Spiess illustrates the article beginning on page 19.

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The Design of an Electrohydraulic Dredge for Clam Surveys

RONALD JOEL SMOLOWITZ and VERNON E. NULK

Introduction

The Northeast Fisheries Center (NEFC) of the National Marine Fisheries Service, formerly the Bureau of Commercial Fisheries, has been conducting clam surveys off the northeastern United States since 1963. Initially these were exploratory surveys mostly concerned with determining the distribution and potential for commercial utilization of the Atlantic surf clam, *Spisula solidissima.* A variety of vessels, gears, and methods were used. These surveys also revealed that a large ocean quahog, *Arctica islandica,* resource existed in the Middle Atlantic region between depths of 40 and 60 m (Murawski and Serchuk, 1979).

In 1977 two important trends forced a change in clam survey procedure. The first was the decline in the surf clam populations due to intense fishing pressure and a massive natural kill in 1976. These factors increased the pressure on the deeper ocean quahog beds. The second trend, the direct result of the Magnuson Fishery Management and Conservation Act, was the need for more consistent and reliable resource data for management purposes. These two trends strengthened the need for an improved standard survey to measure distribution and production potential of both the surf clam and ocean quahog stocks.

The experimental design for the new standard survey consists of performing tows of 5 minutes duration at about 350 depth-stratified but randomly selected stations in depths from 18 to 110 m. A towing speed of 1.5 knots is constantly maintained with the aid of a shipboard doppler speed log.

One of the key requirements of the new survey was to insure that the dredge used could be operated in a consistent and efficacious manner. This was no simple task considering the various depths and substrates the survey sampled.

Existing commercial and survey hydraulic clam dredges operate using a deck-mounted pump to supply water to the dredge via a hose (Fig. 1). The hose, which is 6-10 inches (15.2-25.4 cm) in diameter, is assembled in sections, and the overall length is a function of the depth being worked. Commercial fishermen have found that the dredge efficiency is significantly affected by supply pressure and volume as well as substrate type. Variations in hose length should then also affect dredge operation.

Basic Concept Development

The dredge system in use at the time the choice was made to go to a new survey was a 48-inch (122 cm) surface-supplied hydraulic dredge (Fig. 2). The dredge was of two-piece construction as it was originally built to be handled over the side. Water was supplied by a 6-inch

ABSTRACT—A clam dredge system, using an electrically driven submersible pump, was designed for surf clam, Spisula solidissima, *and ocean quahog,* Arctica islandica, *surveys along the northeast coast of the United States in water depths to 100 m. The 3,200 kg, 5.2 m long dredge has a 1.52 m cutting knife and pumps 7,570 l per minute through the cutting jet manifold. The pump power requirement is 100 amps of 460 V AC 3-phase current provided via a special cable by the ship's 150 kW generators. This paper describes the design of the dredge and the operating experiences to date.*

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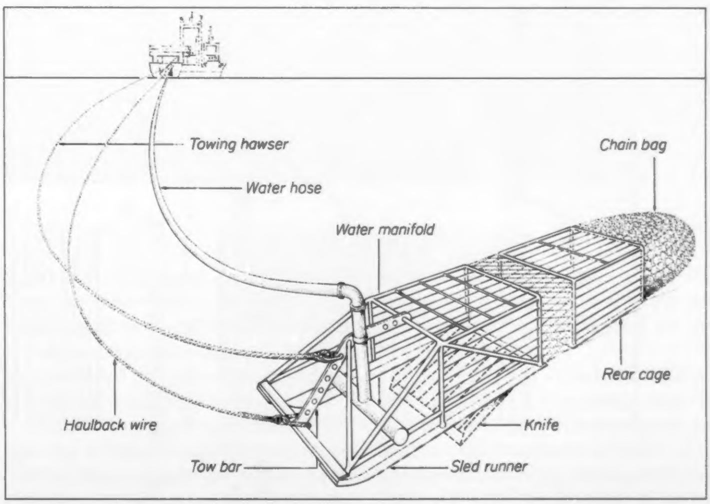

Figure 1.—The older commercial-type dredge was usually of two-piece construction as clammers felt it tended bottom better. It was also easier to handle over the side.

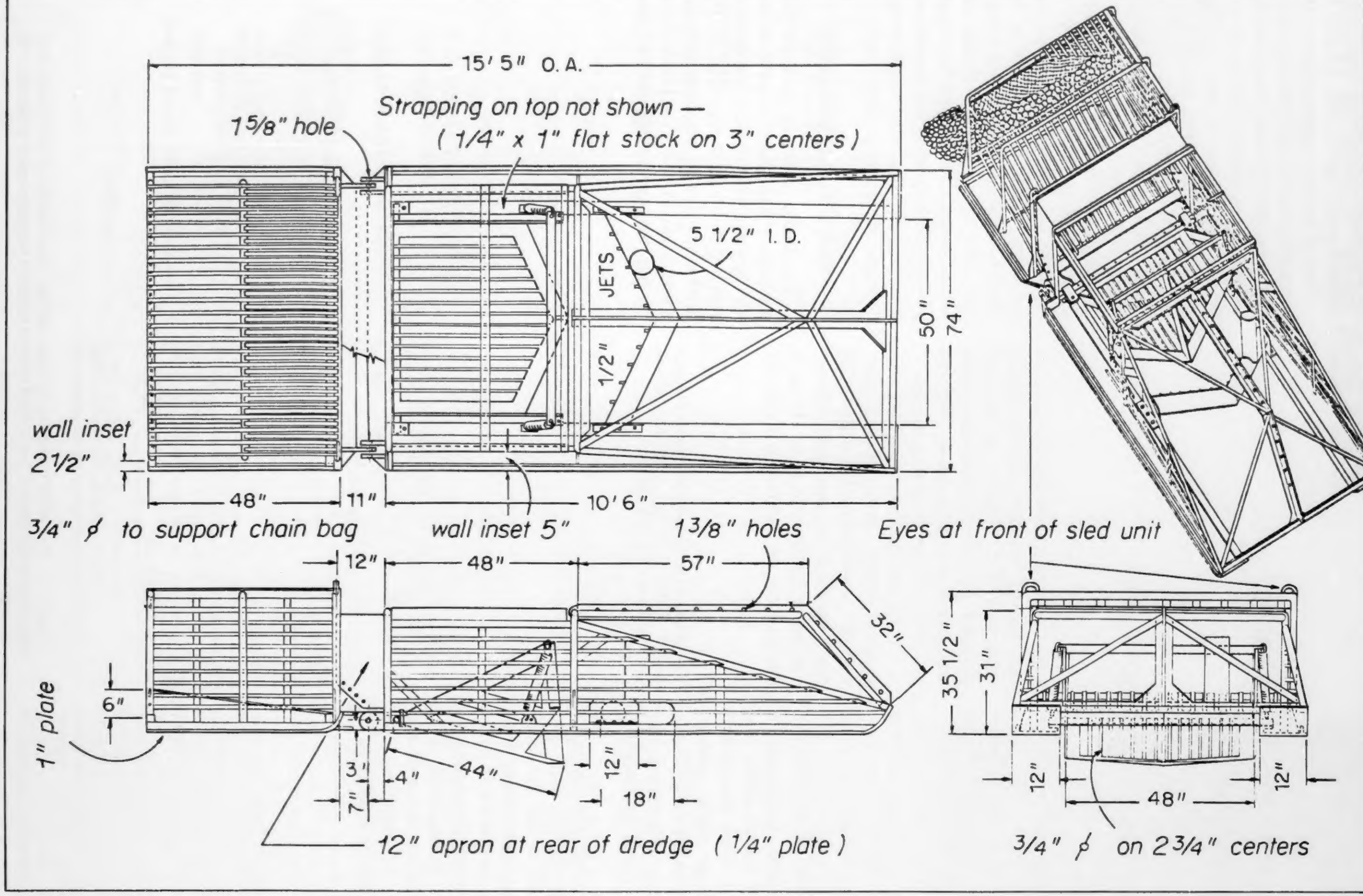

Figure 2.—An early version of the 48-inch (1.22 m) survey dredge with a V-knife and manifold. Later modifications included a straight blade and manifold and eliminated the chain bag.

Figure 3.—The 48-inch (1.22 m) survey dredge modified for electrohydraulic operation. The electric cable to the submersible pump is wrapped with rope for protection from cuts and abrasion.

(15.2 cm) centrifugal pump powered by a 100-horsepower diesel engine mounted on the main deck of the NOAA ship *Delaware II*.

There were several major operational problems with this system. The first was that the dredge was depth limited to about 55 m since its efficiency, due to pressure drop in the hose, was decreased considerably at greater depths. Handling the long and bulky hose was difficult, especially at the greater depths. The dredge itself was apparently too light, 1,360 kg, to fish "hard on the bottom" (never leaving contact with the bottom) when towed by the *Delaware II* under certain conditions of sea, tide, and depth as evidenced by many "water-hauls" (hauled up completely empty).

The most important consideration was that the scientists wanted to sample to 110 m, the maximum known extent of the commercially important clam beds. The deepest the commercial fleet was fishing was 55 m and to do that they were using double hoses attached to massive pumps and engines built into the vessels. There was no way this size equipment could be added to the *Delaware II*.

The NEFC had experience with another method of clamming: Electrohydraulic dredging. The first system was built in 1965 (Standley and Parker, 1967) and was used over the course of the next 7 years (Fig. 3). The *Delaware II*, built in 1968, was designed with ample electric power available to operate the new system. The electrohydraulic dredging

method was abandoned when the prototype system began to experience excessive reliability problems. In 1977, after reviewing these problems, it was decided they could be resolved. Since much of the electrohydraulic system was usable, and there were significant time and money constraints, it was decided to build a second generation system putting the emphasis on a new dredge design as opposed to a completely new approach.

Meetings were held with clam industry representatives and it was agreed that a survey dredge would not have to be as efficient as a commercial dredge for each set of fishing factors (depth, bottom type, etc.) but that it should be roughly based on an industry-type design that could be related to the industry as far as catching efficiency. Ideally, the dredge needed to be a consistent sampler. The operational design problem was stated as follows: To insure the dredge rides squarely on the bottom with blade fully cutting over a known distance and to have the entire catch within the desired size-selection range retained.

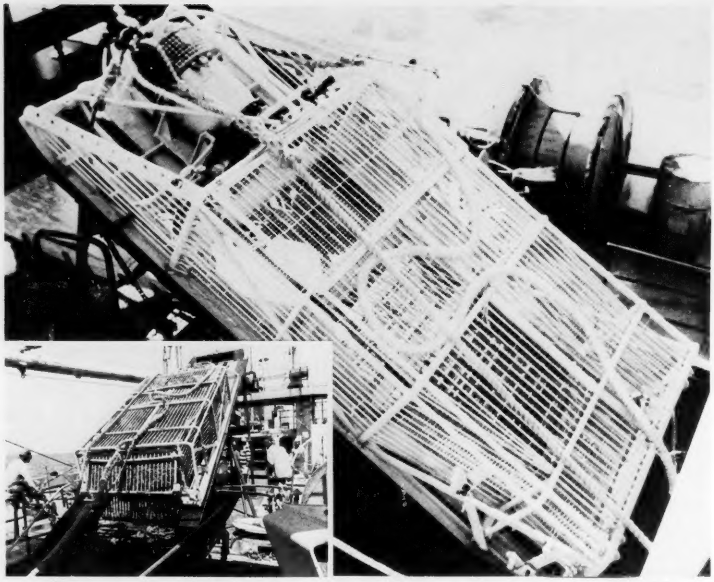

Figure 4.—The 60-inch (1.52 m) electrohydraulic dredge in the "dump" position on the ramp.

Dredge Design

This paper is primarily concerned with the mechanical design of the electrohydraulic dredge. Details of the electrical system can be found in Crossen and Smolowitz (1980).

The first decision made on the dredge design was to increase its size, compared with the old dredge, to increase the sample size collected and dredge weight. A choice of a 152.4 cm (60-inch) wide cutting blade was made, since anything wider would not fit up the stern ramp of the *Delaware II* and this size was common commercially in the event that comparison fishing experiments would be conducted. For the same reason other dredge characteristics, such as bar spacing, were kept similar to industry designs.

It was decided to construct the dredge as one piece to aid in midwater stability and stern docking and undocking (some dredges still are of two-piece construction). The forward section of the dredge was designed to contain the electrically driven submersible pump. Manifold to blade edge distance and cage volume followed industry practice. However, the dredge structure was built extra strong because of rough bottom encountered during random survey tows. The above factors evolved into a dredge length of 5.2 m, width of 2.13 m, and weight of 3,182 kg (Fig. 4).

Blade Design

One major problem with the old dredge was the high frequency of cut clams in the catch. Fishermen have traditionally found that their best surf clam catch rates, with minimum cut clams, was with blade depth (distance between bottom of dredge runner and bottom of blade) set between 5 and 6 inches (12.7 and 15.2 cm). Blade depth for ocean quahogs is usually less, about 4 inches (10.2 cm). The blade depth on the survey dredges was set at 8 inches (20.3 cm) to be able to assume complete sampling free of a depth-related bias.

Over the years, two observations were made relating to the high incidence of cut clams. In heavy weather or when towing down current the dredge, as judged by how the ship handled, was bouncing along on the bottom; thus the blade was passing in and out of the layer of clams in the substrate, resulting in damaged animals. This problem was remedied in the new dredge by making it heavier and by better controlling the speed over bottom by using a doppler speed log.

The other cause of cut clams was the blade mounting method. New Jersey commercial surf clammers had found that by keeping the blade depressed by the use of a spring device, this "floating-knife" would ride over the dense deposits of clay substrate found in that region. The spring usually consists of a steel spring or a number of rubber bands cut from old tire inner tubes. A commercial clammer usually works one geographic region for a period of time. Thus, he adjusts the spring tension to compensate for different bottom types by continuously observing his catch rate and incidence of cut clams. Due to the nature of the clam surveys, the latter feedback process cannot exist, and thus the blade tension is usually too low or too high. In the case of being too low, the blade rides

up in hard compact sands, in many instances cutting right through the clam bearing layer, causing cuts. When the blade tension is too high, the consequence is filling the dredge with clay and/or heavy sediments, thus clogging the dredge early in the tow. It was found during clam surveys that, in general, the higher the spring tension the better the catch rate.

To eliminate any doubt about variations in cutting depth due to blade movement, it was decided to fish the new survey dredge normally with the blade fixed securely 20 cm below the runners. The capability to "float" the blade was still retained. During a routine survey, consisting of about 300 random stations, the blade gets badly "rim-racked" several times due to large rocks or obstructions. A door was provided on the top of the dredge to facilitate removal and replacement of the blade assembly and manifold; the whole job requires about an hour. During exploratory fishing on known "hard" bottom the blade has been spring mounted and has sustained virtually no damage.

Many fishermen feel that keeping the blade edge or "knife" sharp improves the efficiency of the dredge. During the normal course of towing the knife edge gets considerably dented by small rocks. On the new dredge, as with many industry dredges, the knife edge is a separate piece of plow steel bolted onto the blade assembly and is readily replaceable.

One other design consideration was the location of the blade assembly. The blade was located close to the midpoint of the longitudinal axis, as many commercial fishermen feel this placement improves bottom-tending characteristics.

Cage Design

The cage of the old survey dredge, which was built by a commercial dredge maker in 1965, was constructed of 1-inch wide (2.54 cm) flat bar welded between ½-inch (1.27 cm) diameter rods leaving ¾-inch (1.9 cm) spacing between. Without the flat bar the dredge would have had the 2.5-inch (6.35 cm) spacing, almost standard throughout the commercial surf clam fleet.

While the commercial fisherman is primarily interested in retaining surf clams greater than 5 inches (12.7 cm), the scientist needs a complete sample of clams down to 2 inches (5.1 cm). The catch of "prerecruit" clams is used to assess the overall clam population as an aid in determining future harvest.

The problem with decreasing the spacing in the dredge cage is that the dredge tends to clog up rapidly in most substrates. If the dredge does clog before the tow is completed, it effectively stops fishing, thus giving a biased sample.

One of the first considerations in designing the cage was to build it similar to a commercial dredge but with large scantlings to increase weight and ruggedness. The top and sides of the cage were constructed of ⅝-inch (1.6 cm) diameter round stock placed 2⅝-inches (6.7 cm) on center. The bottom of the cage was constructed sloping upwards towards the aft end, the entire bottom being higher than the runners. The ¾-inch (1.9 cm) round stock forming the bottom was alternately staggered in two layers spaced 2¾-inches (7.0 cm) apart on centers when measured diagonally. Commercial fishermen claim this method of construction allows the trash and sediment to wash out more efficiently. In addition, round vs. flat construction materials are believed to provide better flushing action.

The next step was to line the entire cage with a removable liner. The commercial boats fishing for ocean quahogs, a smaller clam than the surf clam, line their surf clam dredges with wire mesh, with anywhere from 1.5- to 2.5-inch (3.8-6.4 cm) openings, usually square mesh. The new survey dredge was first lined with 1×1-inch (2.54 cm^2) vinyl coated wire (14-gauge) mesh because that would give 100 percent retention of 2-inch (5.1 cm) clams. However, subsequent field tests, described later in this paper, indicated rapid clogging, so the liner was enlarged to 2×2-inch (5.1 cm^2) 11-gauge mesh.

The cage is also equipped with several hatches or doors. The entire aft end of the dredge cage is hinged to swing open and dump the entire contents over the ship's stern. This "trash door" is usually used if the dredge is filled with rocks or clay.

The rearmost section of the cage bottom is a catch removal door hinged at its aftermost end. The door is opened by means of a lever mounted on the dredge side. The aft end of the cage, with the trash door, is tapered at an angle so that when the dredge is sitting in the stern ramp the aft end is vertical. This facilitates dumping the catch.

Manifold Assembly

The manifold on the new survey dredge is a bolt-on unit capable of being positioned at different distances from the blade. There are 14 cutting nozzles made of ¾-inch (1.90 cm) diameter, 6-inch (15.2 cm) long pipe nipples angled at 45° to the vertical facing aft. In addition there are two "blowbacks" connected by hose to the blade assembly. The 6-inch (15.2 cm) diameter inlet to the manifold can either be connected to the dredge-mounted submersible pump or to a hose from a surface supply.

Submersible Pump Mount

The submersible pump is mounted onto the dredge with the suction end facing forward. It is bolted into a cradle along the dredge centerline and protected on the bottom by a 1-inch (2.54 cm) thick steel plate. The suction is surrounded by steel plate except for the top section which is covered by a screen. The openings in the screen (12 mm) are smaller than the inside nozzle diameter to prevent gravel from entering and blocking the nozzles. A guard made of steel bar is bolted on over the pump.

To enable the pump to be located in this position, it was necessary to tow the dredge using a bridle arrangement. A heavy steel bar is incorporated into the dredge frame on both sides of the forward part of the dredge with holes for bridle attachment. There are also accommodations made to mount an odometer and counterweight in this part of the dredge.

Operation

The dredge is set and hauled from a stern ramp using a 1-inch (2.54 cm) steel wire rope from the main trawl winch. Once the dredge is on the bottom, a 2-inch (5.1 cm) polypropylene rope connected between the dredge and the ship takes over the load to pull the dredge

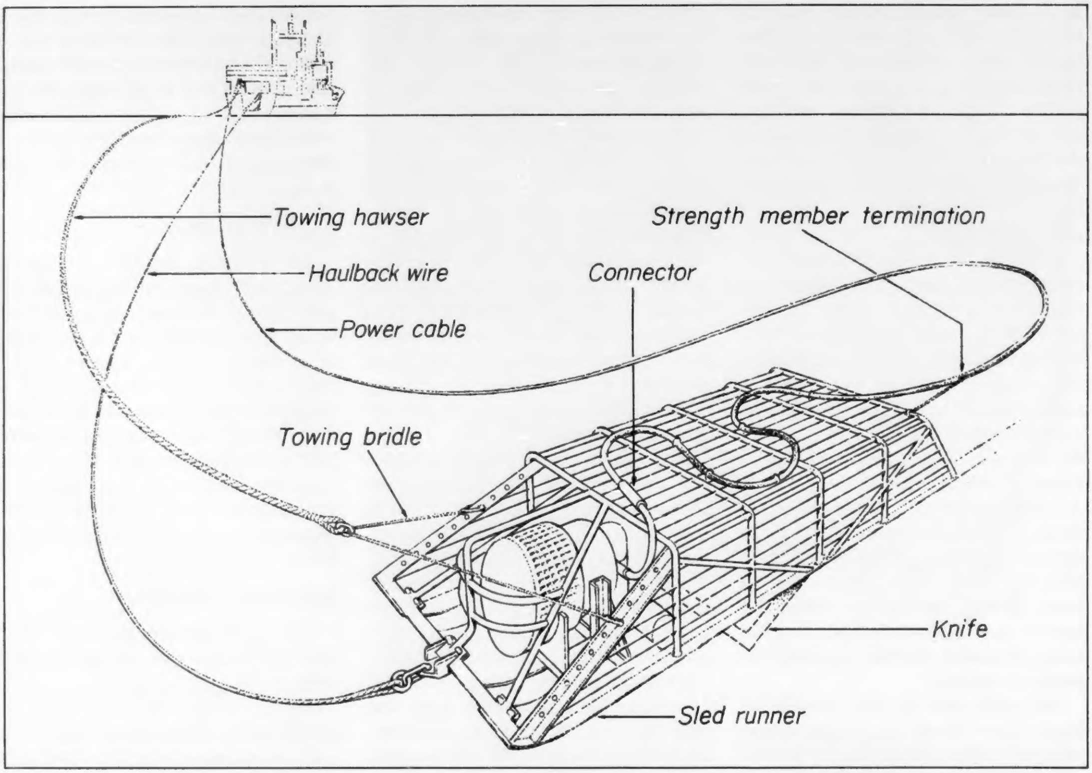

Figure 5.—The dredge is towed by the towing hawser, the hauling wire is kept slack, and the power cable has about 1,500 pounds tension.

along the bottom for the tow duration (Fig. 5). The elasticity of the polypropylene provides a built-in shock absorber. Also, both the steel cable and the plastic rope act as backups for each other. At the same time the dredge is set or hauled, an operator at the electric cable winch is controlling the amount of cable out. During the tow the winch maintains a preset tension on the cable, generally on the order of 1,500 pounds.

The ramp assembly used to carry the dredge aboard the vessel is a 43-foot (13.1 m) long, 8,700-pound (3,955 kg) structure primarily of 10-inch (25.4 cm) vertical "H" beams forming rails 6 feet (1.8 m) apart. Its lower end is set into the stern ramp of the vessel and rises forward at a 30° incline to a height of 15 feet (4.6 m). The lower section of the ramp, 13 feet (4.0 m) long, pivots at water level to enable docking and alignment of the dredge prior to retrieval. Once the dredge is properly aligned, it is hauled to the top of the incline, at which time the catch door in the rear underside of the dredge is opened, allowing the catch to be emptied into a sorting table beneath the ramp (Fig. 6).

Extensive use is made of a doppler speed log to maintain a constant towing speed over the bottom of 1.5 knots throughout the 5-minute standard survey tow. Comparisons made using a loran-C plotter and actual diver measurements of the dredge path confirm that the actual tow lengths are standardized within the confidence limits required for assessment purposes.

Diver observations indicate that the dredge fishes "hard" on the bottom, cutting a uniform trench for the full length of the tow. This is confirmed by catch analysis showing few cut clams.

Clam Dredge Testing

The *Delaware II* was outfitted with the electrohydraulic clam system during a cruise from 13 to 22 August 1979. One of the main objectives of the trip was to collect data on the efficiency and selectivity of the system in catching clams when it was fished in a research survey mode. A similar cruise had been con-

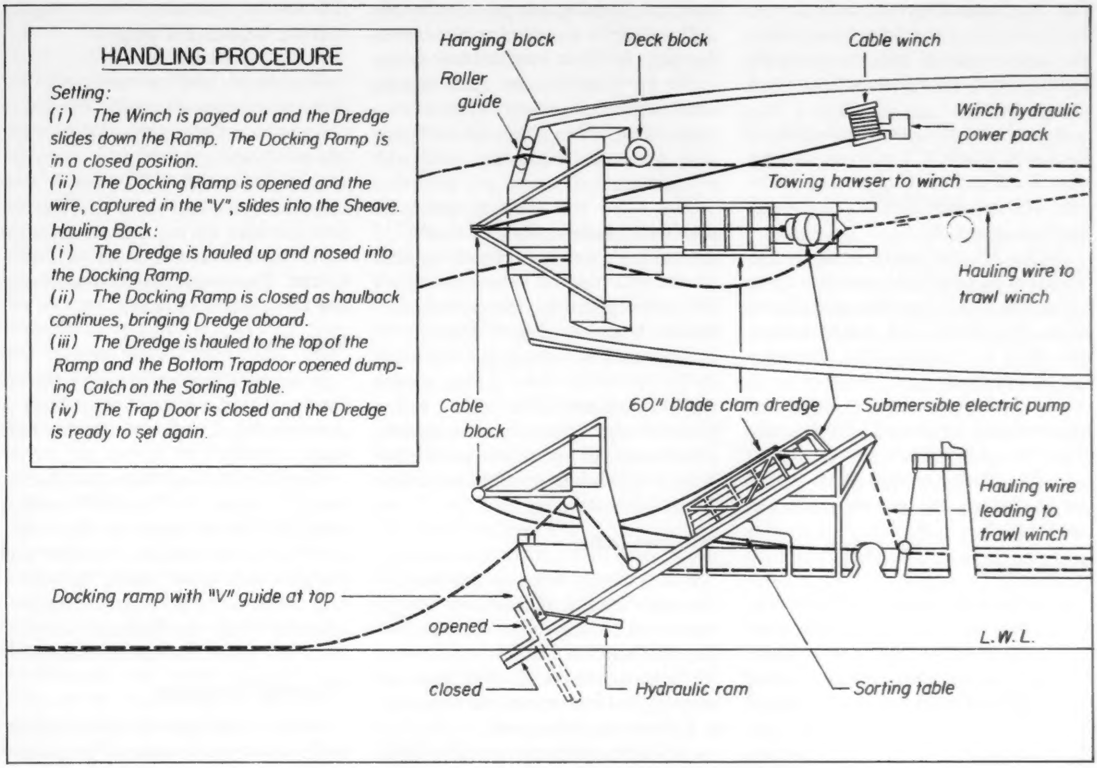

Figure 6.—Stern chute clam dredge ramp used aboard the *Delaware II*.

ducted in the past using the old survey dredge, some of the results of which are described in Meyer et al. (1981).

Seventy-seven tows were made, 10 of them observed by divers, along the south coast of long Island, N.Y., and along the New Jersey coast south to Atlantic City (Table 1).

Table 1.—Tow summary for *Delaware II* Cruise 79-08, 13-22 August 1979.

Tow no.	Position Lat.	Position Long.	Depth (m)	Remarks
1	40°53'N	72°09.5'W	27	
2-17	40°25'N	72°23.6'W	55	Marked clam area
18	40°45.6'N	72°39.6'W	18	
19	40°46.9'N	72°36.2'W	18	
20	40°50.1'N	72°25.2'W	18	
21	40°50.5'N	72°23.1'W	18	
22	40°50.5'N	72°23.1'W	18	Divers' survey path
23	40°51.7'N	72°21.5'W	16	Divers' film dredge
24	40°44.9'N	72°40.1'W	24	
25	39°16.2'N	74°20.4'W	16	
26	39°19.0'N	74°20.7'W	15	
27	39°19.3'N	74°16.2'W	15	
28	39°17.2'N	74°28.5'W	13	
29	39°25.8'N	74°12.0'W	18	
30	39°25.4'N	74°11.9'W	16	Divers' survey path
31	39°25.5'N	74°11.8'W	18	"
32	39°23.7'N	74°11.0'W	18	
33	39°25.5'N	74°11.8'W	18	"
34	39°25.5'N	74°11.8'W	18	"
35	39°25.5'N	74°11.8'W	18	
36	39°23.3'N	74°18.0'W	11	
37	39°34.5'N	74°12.5'W	9	
38	39°35.0'N	74°12.8'W	7	
39	39°37.4'N	74°10.5'W	11	Packed w/clay
40	40°33.0'N	73°50.0'W	9	Divers' survey path
41	40°33.5'N	73°51.0'W	7	
42	40°33.3'N	73°51.0'W	7	Divers' ride dredge
43	40°33.0'N	73°50.0'W	9	Divers' survey path
44	40°33.0'N	73°50.0'W	9	
45	40°33.8'N	73°43.0'W	11	
46	40°34.3'N	73°41.7'W	9	
47	40°34.6'N	73°31.8'W	9	
48	40°36.9'N	73°15.9'W	9	
49	40°36.9'N	73°13.9'W	13	
50	40°37.1'N	73°10.9'W	16	
51-77	40°25'N	72°23.6'W	55	Marked clam area
78	40°56.0'N	72°11.0'W	16	Divers' film dredge

Diver Dredge Observations

The following is a summary of some of the information provided by diver observation:

1) There was more than sufficient water flow from the pump for proper digging action of the nozzles. At slow speeds, up to 1 knot, the jets dug deeper

than the blade. However, path surveys didn't show any clams being blown under the blade or deep into the cut path. Cutting depth was in inverse function of dredge speed.

2) In abnormally dense clam beds off Rockaway Beach, N.Y. many small clams were found in the first 15 m of each tow path. This may indicate selection through the blade assembly.

3) The 2.5 cm square lined dredge tended to fill rapidly, in most test areas before the first 75 m of the tow. Upon filling, the dredge still dug, but blew everything to the sides and no longer sampled properly.

4) No flushing was observed out of the top or sides of the dredge. Flushing took place through the bottom and rear panels.

5) The dredge towed much easier (lower engine rpm required) with the pump on.

Video Taping

A Sub-sea Systems CM-40[1] underwater color television camera was used to document the dredge in operation. The camera was used in three modes: Diver held, dredge mounted, and surface lowered. Lighting was provided by two 250-watt lights mounted on the camera housing. A 150 m long multiconductor cable provided for the video signals, camera power, lighting, and diver communications. The cable was handled on deck using a hand-powered winch with 14 sliprings.

The video and audio signals were monitored on the surface with a JVC 33 cm color TV monitor (Model No. 4280 m) and recorded on video tape with a JVC color portable video cassette recorder (Model No. HR-410DA).

Five hours of video tape were made on the operation of the cutting nozzles and the blade and of the flushing action of the dredge cage at various speeds. The lowering of a camera in areas previously dredged enabled inspections of the dredged trenches.

Substrate Testing

It is generally believed that bottom type significantly affects clam dredge operations. During this cruise a preliminary attempt was made to classify the different substrates. To this end, the following test equipment (manufactured by Soiltest, Inc.) was used:

1) Pocket penetrometer (CL-7000) with 2.54 cm diameter adapter foot (CL-701),

2) Torvane torsional vane shear device (CL-600 with sensitive vane adapter (CL-602, 0.0-0.2 TSF range),

3) Sand grading chart (A-17).

The hardest sand encountered by the divers was on tow station 33. The divers collected a sample using a large coffee can as a corer and brought it up to the surface for analysis. The sample was classified as coarse sand, subrounded with granules having a penetration of 0.047 kg/cm^2 and a shear of 0.008 kg/cm^2. The dredge had no trouble cutting through this substrate.

Main Winch Tension Test

A hydraulic load cell was attached to the deck haulback block to provide a direct reading of the tension on the main wire.

Maximum tensions during haulbacks averaged about 10,000-13,000 pounds with brief peak loads up to 17,000 pounds. At tow station 39, when the dredge was fully on board, the winch stalled at about 18,000 pounds of tension. After the dredge was flushed of some of its catch, it was able to be hauled aboard.

Operating Parameters

Of the 77 tows, 43 were made primarily in an attempt to recover previously marked clams in a small area that seemed to have a relatively uniform distribution of ocean quahogs. We took advantage of this by varying operating parameters to determine what effects, if any, they had on catch rate (Table 2).

Tow Stations 2-17

Scope was varied from 1.6:1 to 3:1 with no apparent effect. The length of tow was also varied from 3 to 15 minutes with no apparent effect on catch rates. These observations were probably due to the dredge filling rapidly and then just acting as a plow. Catches from tows 2-17 varied from 120 to 403 clams, the average being 246 clams. During tow 16 the dredge was operated with the pump off and caught 176 clams. The mesh size throughout these stations was 2.54 cm^2.

Tow Stations 51-77

Tow stations 51-77 were all fished at a constant speed (1.5 knots), scope (2:1), and duration (5 minutes).

On tows 51-57 the pump was not

Table 2.—Catch data (number of clams) from test tows.

Tow no.	Catch	Tow no.	Catch	Tow no.	Catch	Tow no.	Catch	Tow no.	Catch
2	131	51	169	58	456	63	144	70	571
3	120	52	104	59	316	64	392	71	513
4	145	53	231	60	354	65	489	72	518
5	403	54	261	61	400	66	272	73	414
6	129	55	178	62	109	67	550	74	523
7	198	56	215			68	343	75	564
8	362	57	255			69	357	76	898
9	152							77	513
10	352								
11	307								
12	293								
13	353								
14	378								
15	280								
16	176								
17	155								
$\overline{X}$ =	245.88		201.86		327.00		363.86		564.25
SD=	104.12		55.63		132.61		134.39		142.98
SE=	26.03		21.03		59.30		50.79		50.25
±2SE=	193.82		159.80		208.40		262.28		462.67
	297.94		243.92		445.60		465.44		665.83

[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

turned on until the dredge was on the bottom and strain was placed on the towing hawser. The average catch was 202 clams. On tows 58-62 the pump was turned on before the dredge hit the bottom. The average catch increased to 327 clams. This technique probably allowed the dredge to fish a little longer before filling up and thus was used on all subsequent tows.

On tows 63-69 the rear mesh panel was changed to 5.1 cm square mesh. The average catch for these tows increased to 364 clams. On tows 70-77 the rear bottom panel mesh was also changed to 5.1 cm^2 mesh and the average catch increased to 564 clams per tow. This indicates, along with diver observations, that most of the washing action, and probably selection, occurs on the dredge's bottom.

Throughout the above tests, despite the mesh size modifications, the size distribution of the clams retained did not appreciably change. A possible explanation for the lack of differential selectivity is that shell, sand, and live invertebrates may have clogged the dredge at the beginning of the tows, negating further filtering ability (Murawski et al., 1980). Actually, as seen by the overall change in catch rates, there apparently was a change in filtering ability but not enough to influence selectivity in this test area and for the population size/structure present.

Path Surveys

Divers conducted detailed surveys on six dredge paths. The procedure used was as follows: The ship set the dredge, with a buoy attached, heading down current and anchored up on the dredge. The divers, tended from a Zodiac rubber boat, descended to the dredge and marked the starting point with an anchor and buoy. In addition, they placed a reel of marked (leaded) line on the bottom and attached one end to the rear of the dredge. When they were ready they moved clear of the dredge and signaled the surface to start the tow. The ship turned the pump on and commenced towing. Using a Northstar loran-C/EPSCO plotter, a doppler speed log, and an estimate of the distance between the dredge buoy and anchor buoy, the ship towed long enough to make a 50 m path. Upon completion of the tow, the pump was stopped and the ship anchored-up on the dredge.

After the pump was shut off, the divers read the lead line to get the path length. They then proceeded down the path collecting any clams on the surface in the dredge area.

Using 0.25 m^2 grid squares, they took random samples both inside and outside the path.

Table 3 presents the results from three path surveys made in the same area off the coast of Brigantine, N.J., in 18 m of water.

Due to the small number of clams found during tow number 31 by diver sampling, we increased the sampling in tows 33 and 34 to 30 grid samples inside and 30 grid samples outside the paths. The data from tows 33 and 34 were then combined and the standard error of the grid samples was calculated to find the 95 percent confidence limits. Using these limits, the efficiency based on the dredge catch divided by the total clams found in the path (*E*) was calculated to lie between 74.9 and 87.9 percent of $\overline{X} = 83.1$ percent, which is reasonable. However, in a similar manner, the efficiency based on outside the path grid densities (*D*), lies between 100.1 and 529.7 percent or $\overline{X} = 168.3$ percent, which is too high. These results make both efficiency calculations suspect, possibly indicating insufficient sampling or diver undersampling. One other possibility is that clam distributions are spotty in nature and the assumption that clam density to either side of the path is similar to that within the path, is wrong within our limited sampling regime.

Discussion

Clamming, regardless of the species, area, or method, simply involves digging through substrate and gathering clams. Research on soft-shell clams, *Mya arenaria*, has shown that efficiency (percent removals) and breakage (mortality on clams remaining) using hand-harvesting techniques is a function of the fisherman's skill and method (Medcof and MacPhail, 1952, 1967; Dow et al., 1954; Glude, 1954). Improvements in efficiency, nearing 100 percent, and reductions in breakage came about with the introduction of hydraulic escalator dredges into this fishery (Dickie and MacPhail, 1957; Manning, 1957, 1960; MacPhail, 1961; Medcof, 1961). As with hand methods, the efficiency and effects of hydraulic dredging are highly variable depending on location, bottom type, clam density, gear design, weather, and operator skill. The long-term effects of an indirect nature, such as sediment clouds covering the bottom or sand particles damaging the animals, have been hard to observe and document.

Hand methods of clamming, such as

Table 3.—Path survey results from three stations in the same area occupied on *Delaware II* Cruise 79-08, 13-22 August 1979.

Observation or measurement	Tow no. 31	Tow no. 33	Tow no. 34	Tows 33 and 34 combined
Path length	61 m	58 m	56 m	—
Width	1.52 m	1.52 m	1.52 m	—
Path area	92.72 m^2	83.16 m^2	85.12 m^2	173.28 m^2
Dredge catch (A)	106	93	82	175
Surface catch (B)	12 (9 damaged)	20 (9 damaged)	4 (3 damaged)	24
Path samples catch (0.25 m^2)	1,0,0,0,0,0	1, 29-0's	30-0's	1, 59-0's
Density of pathg clams remaining	0.66 clams/m^2	0.13 clams/m^2	0	0.067 clams/m^2
Total patch clams remaining (C)	61	12	0	11.55
Outside samples catch (0.25 m^2)	2,1,1,1, 8-0's	1,1,1,1,1, 25-0's	2,1,1, 27-0's	2,7-1's 52-0's
Density of outside clams	1.66 clams/m^2	0.66 clams/m^2	0.53 clams/m^2	0.60 clams/m^2
Total clams in patch before tow based on grid densities (D)	154	58	45	104
Total clams found in path (A+B+C=E)	179	125	86	210.5
Efficiency based on (D)	68.8%	160.0%	182.2%	168.3%
Efficiency based on (E)	59.2%	74.4%	95.3%	83.1%

raking and tonging, were used in the surf clam fishery (Parker, 1971) and are still used in the inshore quahog, *Mercenaria mercenaria*, fishery. In the 1920's, towed nonhydraulic dredges, or "dry" dredging, came into use in these fisheries but not without controversy which still exists today. Glude and Landers (1953) compared the effects of hand raking and power dredging and found no biological basis for restricting either method of fishing.

In the surf clam fishery, development continued on into hydraulic dredging due to the increased efficiency (Parker, 1971) and the fact that dry dredging crushed surf clams (Ruggiero, 1961). Medcof and Caddy (1971) found that a skillfully controlled hydraulic dredge was close to 100 percent efficient in catching ocean quahogs. In comparison they found a dry dredge less than 1 percent efficient and broke the shells of 80 percent of the uncaught clams.

Experiments conducted with the old NEFC hydraulic survey dredge gave results similar to those reported above: Efficiency that could approach 100 percent (Meyer et al., 1981). Efficiency, in both studies, was found to be a function of towing speed, scope, and the relationship between cutting blade and hydraulic nozzles. Observations of the survey dredge proved that, once the dredge filled, efficiency dropped to zero and the dredge became a tool of destruction along the bottom.

Testing of the new electrohydraulic survey dredge, some of which has been reported in this paper, indicates that this dredge can also be highly efficient. An analysis of 10 tows in the marked quahog area indicates that less than 3 percent of the catch suffered cuts due to dredging action. The question arises about how a dredge can be fine-tuned to maximize its efficiency and minimize destructive effects. To answer this question requires an understanding of the exact mechanism, or functional principle, of dredge operation.

One of the first clues on how a hydraulic dredge works was observed by Medcof and MacPhail (1964) during development of a hydraulic rake to harvest soft-shell clams. Using laboratory aquaria and field tests, they determined that the hydraulic nozzles, or water jets, were converting the clam-bearing substrate from a solid to a fluid state: A slurry. The clams, being less dense that the slurry, become buoyant and pop up to the slurry surface. Based on this observation they presumed there was a large amount of tolerance in the design of the hydraulic system as long as the fluidizing function was maintained.

The slurring action is a function of water jet volume, pressure, and flow, as well as dredge speed. Diver observations by Medcof and Caddy (1971), confirmed by our divers during field tests, show that when the dredge is towed too slowly for a given set of hydraulic parameters, the slurring action becomes an excavating action, digging a trench deeper than the "cutting" blade of the dredge. Correspondingly, when the dredge is towed too fast, it either comes out of the bottom or rapidly fills with substrate and performs a "plowing" action.

During the efficiency tests conducted with the new survey dredge, the divers made some general observations of bottom hardness using their hands. On hard sand bottom before the dredge made a pass they could barely get their fingers to penetrate, but after the dredge passed they could stick their entire arm up to the elbows into the substrate in the dredge track.

Robert Frost, of the clammer *Wando River* out of Warren, R.I., heard of this observation and realized the clams would tend to float up out of the fluidized bottom. He decided to modify his 60-inch (1.52 m) hydraulic ocean quahog dredge to make use of this principle. He increased his hydraulic manifold-to-blade-distance to 48 inches (1.2 m), increased the water flow, and decreased the blade depth to 3 cm. Towing between 2 and 3 knots he almost doubled his catch rate. Making use of a flow meter and remote pressure gauge, Frost found that at his towing speeds his greatest catch rates occurred at 50 gpm (190 lpm) per inch (2.54 cm) of blade width. Realizing that speed is a critical factor, Frost plans to purchase a $14,000 doppler speed log to improve his operation.

Frost's increased catch rate does not mean that his dredge efficiency, as measured by percent removal, has increased. What may be happening is that clogging due to substrate filling the dredge has decreased, and that with the increase in speed the dredge is effectively fishing a greater area of bottom before it fills and plows. This may be economically efficient for a commercial operation, but is not desirable for a survey mode.

Knowing that there is a relationship between towing speed and water volume that can change and still permit 100 percent dredge efficiency, allows for new design considerations. In the electrohydraulic dredge operation, if the water volume requirement can be cut significantly, at whatever sacrifice in towing speed, the initial system cost would drop considerably and reliability would be greatly enhanced.

A better understanding of the "bed fluidization" requirements of the clam harvesting process is needed. This, in turn, could be used to improve manifold/nozzle design, an area of high fluid "losses" in both commercial surface-supplied dredges and the electrohydraulic dredge. Improvements in this area alone probably would result in significant energy savings to the commercial clam industry.

Acknowledgments

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Appendix A

Dredge Hydraulics

If the new information available indicates that water volume requirements can be decreased, then the use of a surface supply to the new survey dredge needs to be reconsidered. At the same time it would be interesting to theoretically examine the head losses due to the manifold/nozzle design and see if this arrangement can be improved. In this section we are going to compare a surface to a submersible-supplied system under today's operating conditions, to provide a starting point for future work in the above areas.

Standley and Parker (1967), during the development of the first electrohydraulic dredge, instrumented for pressure and flow both surface-supplied and submersible pump operations. They presented the following data for the surface pump:

Length of hose (L) = 250 ft
Diameter of hose (D) = 0.5 ft

	Flow (Q) gpm
Case I	1,475
Case II	1,825

	Pressure difference (Δp) psi
Case I	17
Case II	27

Using this data we can calculate the roughness height (ϵ) for the clam hose.

Case I

$$\text{Discharge } Q = 1{,}475 \text{ gal/min} \times \frac{1 \text{ min}}{60 \text{ sec}} \times \frac{1 \text{ ft}^3}{7.46 \text{ gal}} = 3.295 \text{ ft}^3/\text{sec}$$

$$\text{Velocity } V = \frac{Q}{A}$$

$$A = \pi r^2 = \pi\left(\frac{1}{4}\right)^2 0.19636 \text{ ft}^2$$

$$V = \frac{3.295}{0.19636} = 16.7812 \text{ ft/sec}$$

Using the Darcy-Weisbach equation

$$h_f = f\frac{L}{D}\frac{V^2}{2g} ,$$

$$h_f = \text{head loss} = \Delta p = 17 \text{ lb/in}^2 \times \frac{144 \text{ in}^2}{1 \text{ ft}^2} \times \frac{1 \text{ ft}^3}{64 \text{ lb}} = 38.25 \text{ ft}_{\text{water}}$$

substituting to solve for friction factor f

$$\frac{(38.25)\ (32.2)}{(250)\ (281.608)} = f = 0.0175.$$

Using the Moody diagram from Streeter (1966),
$f = 0.0175$, $VD'' = 100.68$, and
$\frac{\epsilon}{D} = 0.0005$,
roughness height ϵ is 0.00025 foot.

Case II

$$Q = 1{,}825 \text{ gal/min} = 4.077 \text{ ft}^3/\text{sec}$$

$$V = \frac{Q}{A} = \frac{4.077}{0.19636} = 20.76 \text{ ft/sec}$$

$$h_f = 27 \text{ lb/in}^2 = 60.75 \text{ ft}_{\text{water}}$$

substituting into the Darcy-Weisbach equation,

$$60.75 = f\frac{(250)\ (20.76)^2}{(0.5)\ (2)\ (32.2)}$$

$$f = 0.0182$$

$$VD'' = 124.58$$

from Moody diagram $\frac{\epsilon}{D} = 0.006$
thus $\epsilon = 0.0003$ ft.

From the results of these two cases we will assume that the roughness height for the clam hose is 0.00028 foot. This is a composite roughness height which takes into account minor losses created by hose fittings, etc.

Goodyear Rubber Company, one of the manufacturers of rubber clam hose, has standard loss charts that give the head loss for 6-inch diameter rubber hose as 8.8 psi per 100 feet of hose at 1,800 gpm. This works out to a roughness height of 0.00015 foot.
Thus $8.8 \text{ lb/in}^2 \times 2.5 = 22.0 \text{ lb/in}^2$ head loss for 250 ft,

$$\text{or } h_f = 22.00 \text{ lb/in}^2 \times \frac{144 \text{ in}^2}{1 \text{ ft}^2} \times \frac{1 \text{ ft}^3}{64 \text{ lb}} = 49.5 \text{ ft}_{\text{water}}.$$

As expected this theoretical head loss of 49.5 feet is lower than the Case II head loss of 60.75 feet. The difference is possibly due to "minor losses" caused by the catenary the hose takes while being towed as well as the hose fittings. Actually the so-called minor losses can be

highly significant in the clamming operation.

For the comparison of the surface vs. submersible supply systems we chose to look at an operating depth of 300 feet; the maximum limit of the commercial-size clam populations now known. Using two to one scope this will involve hose lengths of 600 feet. We chose 2,000 gpm as the flow rate as this is about the lower industry limit for 60-inch dredges.

Specific gravity is about 1.025 for seawater, but for the purposes of this discussion we will neglect it, as it will have little significance on these calculations.

Surface Supply Loss Calculations

Suction losses (see Fig. A-1):

$V_s = \dfrac{Q}{A}$

$Q = 2{,}000 \text{ gpm} = 4.47 \text{ ft}^3/\text{sec}, D_s = 8'', r = 4'' = 0.33'$

$A = \pi r^2 = 0.342 \text{ ft}^2$

$V_s = 13.07 \text{ ft/sec}$

$H_{ss} = \text{static head loss} = 15 \text{ ft}$

$H_{sv} = \text{velocity head loss} = \dfrac{V^2}{2g} = \dfrac{13.07^2}{64} = 2.67 \text{ ft}$

$H_{sf} = \text{frictional losses} = f\dfrac{(L_s + L_e)}{D_s}\dfrac{(V_s)^2}{(2g)}$

$L_s = \text{suction line length} = 21 \text{ ft}$

$D_s = \text{inside diameter} = 0.66 \text{ ft}$

L_e = equivalent length due to "minor losses"

$f = \text{friction factor} = 0.018$

$L_e = \dfrac{KD}{f}$ K = 2 elbows = 1.90; 1 swing check = 2.50; K_{total} = 4.40

$L_e = \dfrac{4.4\,(0.66)}{0.018} = 161.33 \text{ ft}$

$H_{sf} = \dfrac{(0.018)\,(182.3)\,(13.07)^2}{0.66(64)} = 13.27 \text{ ft}$

$H_{se} = \text{entrance head loss} = \dfrac{0.5V^2}{2g} = 1.33 \text{ ft}$

Total suction losses $= 32.27 \text{ ft}_{water}$ (14.2 psi)

Discharge losses:

$V_d = \dfrac{4.47}{0.19636} = 22.76 \text{ ft/sec}$

$H_{dv} = \dfrac{(V_d^2 - V_s^2)}{2g} = \dfrac{22.76^2 - 13.07^2}{64} = 5.42 \text{ ft}$

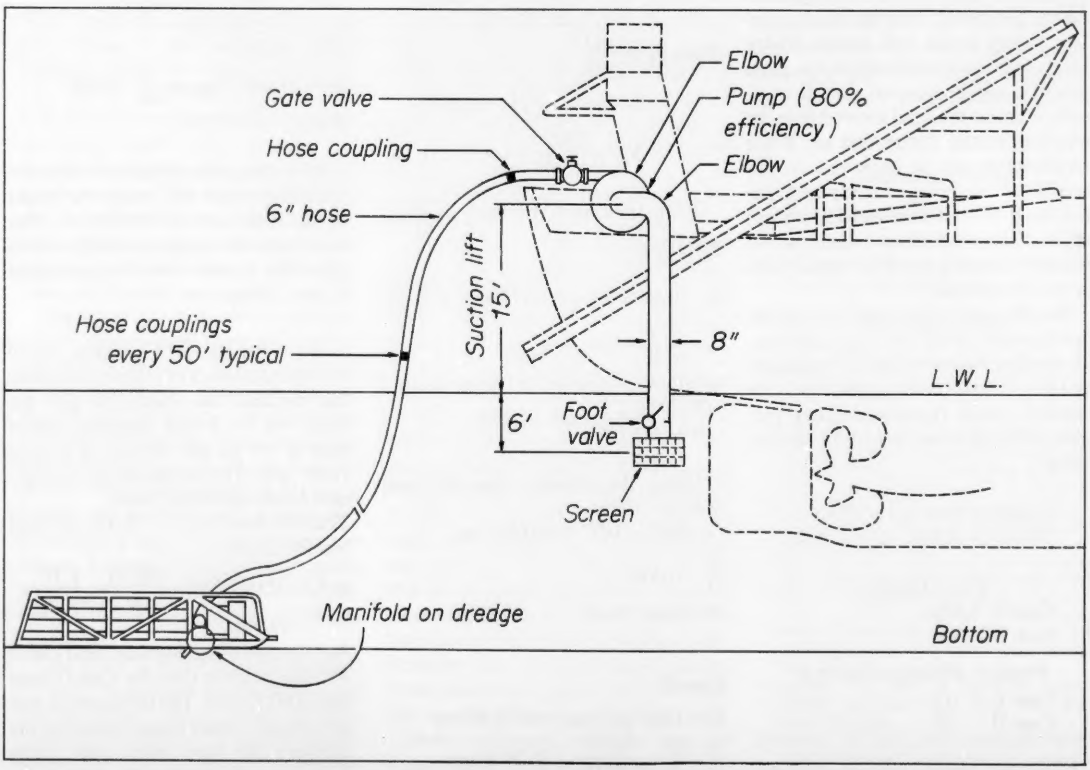


Figure A-1.—Schematic of surface-supplied clam dredge system.

$f = 0.018$
$L_d = 600$ ft
$D_d = 0.5$

$$H_{dl} = \frac{f(L_d + L_e)V_d^2}{D_d(2g)}$$

K = 1 elbow = 0.90
gate valve = 0.19
$K = 1.1$

$$L_e = \frac{(1.1)(0.5)}{0.018} = 30.5 \text{ ft}$$

$$H_{dl} = \frac{(0.018)(630.5)(22.76)^2}{(0.5)(64)} = 183.7 \text{ ft}$$

Total discharge losses =
189.12 ft_{water} (83.2 psi)

Horsepower (water) required to overcome losses:

$$HP_w = \frac{Q\,H_{total}}{3{,}960}$$

$$= \frac{(2{,}000)(189.12 + 32.27)}{3{,}960}$$

$$= 111.8 \text{ HP.}$$

Assume requirements entering dredge manifold are 2,000 gpm at 100 feet of head (44 psi):

$$HP_w = \frac{(2{,}000)(100)}{3{,}960} = 50.50$$

Total water horsepower required = 162.3. Brake horsepower required using 80 percent efficiency of a high head, high capacity end suction centrifugal pump

$$= \frac{162.3}{0.8} = 202.9 \text{ brake horsepower}$$

required to drive a surface pumping system using 6-inch discharge hose.

There is a simple method to decrease the horsepower requirements: Use a larger diameter discharge hose. The following information was extracted from the standard loss tables found in the Goodyear Technical Information Bulletin (821-947-850; 3/77):

Hose dia. (I.D.)	Flow (gpm)	psi per 100′	psi per 600′	HP_w
6-inch	2,000	16.5	99.0	112.5
	3,000	—[1]	—[1]	—
8-inch	2,000	2.2	13.2	15.0
	3,000	4.5	27.0	46.0

Eight-inch hose is very attractive from an hydraulic efficiency standpoint but presents a handling problem. Advances in hose technology in the area of strong, lightweight flat-reeling hose may solve this problem.

Submersible Supply (Gorman-Rupp Model S8A1) Loss Calculations

$$\text{Three-phase kilowatts} = \frac{\text{Volts} \times \text{Amps} \times \text{Power factor} \times 1.732}{1{,}000}$$

Readings from operations: Volts = 460
Amps = 100
From Power curves: Kilowatts = 70
Substituting and solving for Power factor:
Power factor = 0.88.

$$\text{Motor efficiency} = \frac{746 \times \text{Horsepower}}{1.732 \times \text{Volts} \times \text{Three-phase amps} \times \text{Power factor}}$$

From motor performance curves at 70 kw input, hp at 460V = 85, amps = 103.
Substituting and solving for efficiency, Motor efficiency = 87.8 percent.

$$\text{Pump efficiency} = \frac{\text{gpm} \times \text{head in feet}}{3{,}960 \times \text{hp (to pump)}}$$

From curves gpm = 2,200 at 90′ head, hp = 85.

Substituting, pump efficiency = 60%.

From the above analysis and the pump manufacturer's pump and motor performance curves it takes about 85 horsepower to maintain 2,000 gpm at 100 feet of head at the manifold using our submersible pump system. Since the water horsepower requirement, as shown previously, is 50.5 hp, the losses are about 35 hp. This is far better then the 112.5 hp losses for the 600 feet of 6-inch hose but not as good as the 15 hp for the 600 feet of 8-inch hose.

Most of the submersible system losses are due to the low pump efficiency of 60 percent. The particular pump used was designed for other purposes, where tradeoffs were made against efficiency. If we placed a high efficiency (80 percent) centrifugal pump, similar to the surface supply system, on the dredge and powered it by a submersible electric motor, we would cut the losses to 17 horsepower, which is comparable to the losses in 600 feet of 8-inch hose.

There are some losses in the electrical cable but they are not very significant, as the following calculation for the voltage drop in 1,000 feet of GGC (#1AWG) cable demonstrates:

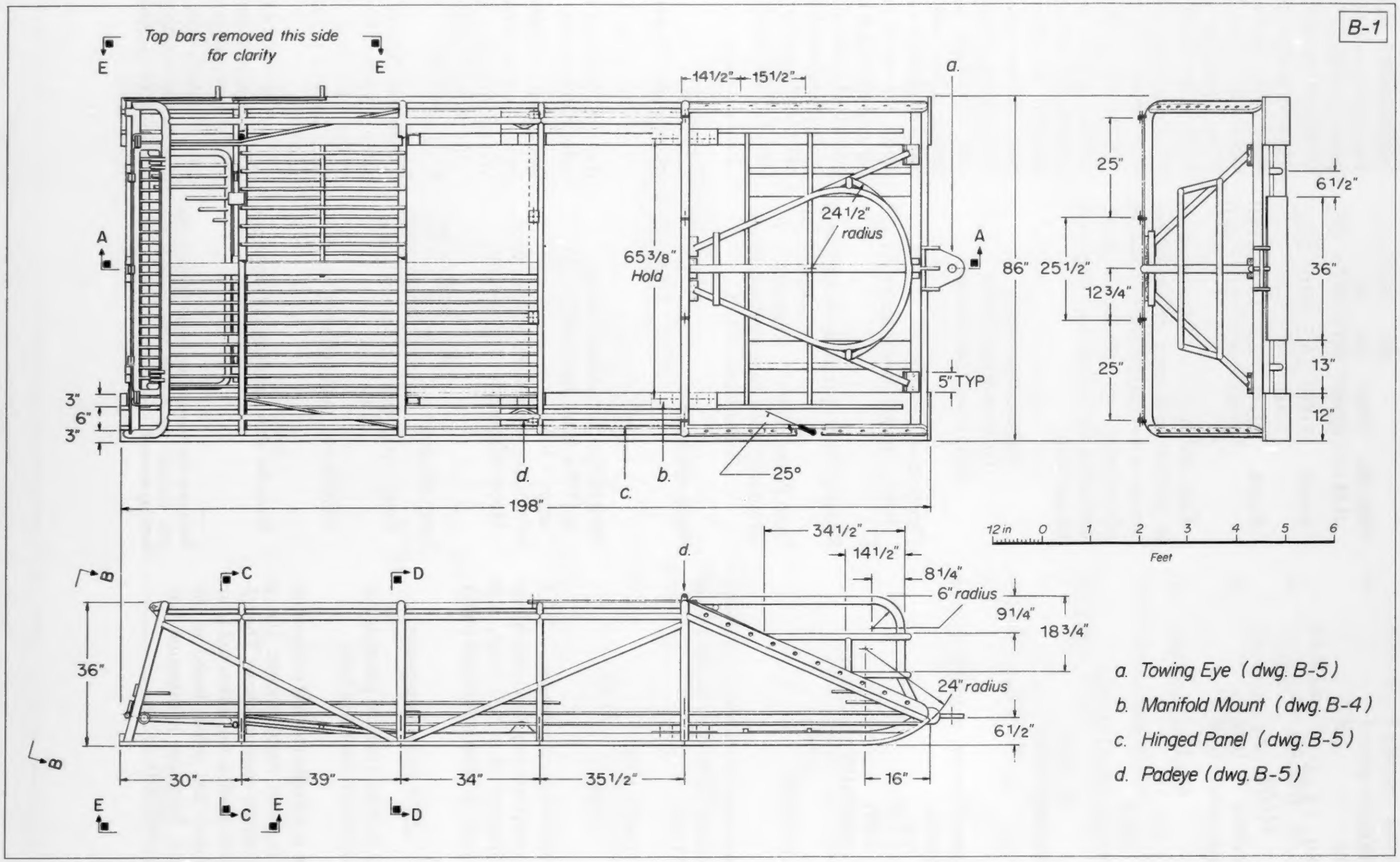
Resistance of #1AWG per 1,000 feet at 25°C copper stranded = 0.134 ohms
Voltage drop (E) = $IR \times 0.865$
(for 3 phase) using 100 amps
$E = 11.59$ volts.

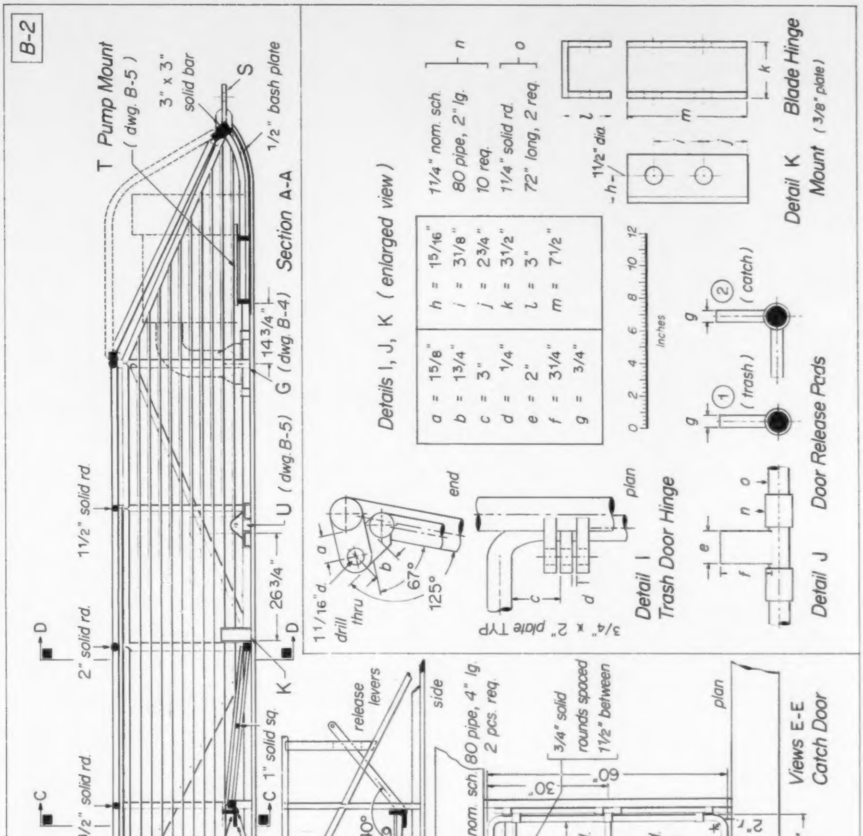
If voltage at the controller is 460, at the pump it will be 448.41 or a 2.5 percent IR drop. For most electric motors this will result in a 1-2 percent drop in efficiency.

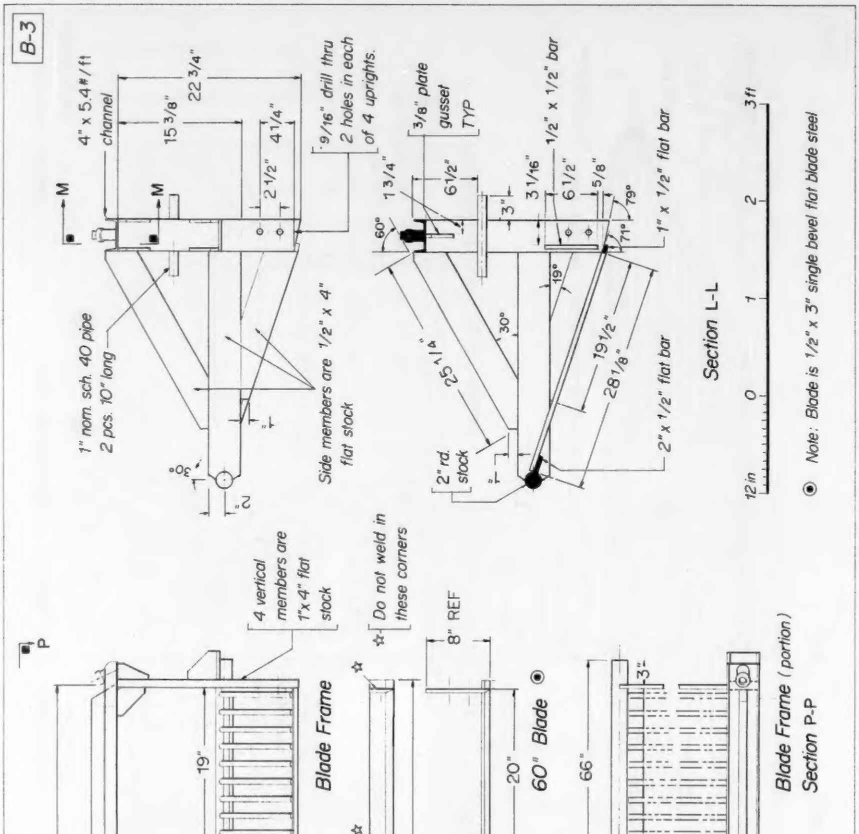
One other area of loss in the electrohydraulic dredge system is the generator. Most generators operate at about 90 percent efficiency. The 10 percent losses here can be roughly equated to the suction losses of a surface-supplied system.

[1]Note that the pressure required to drive 3,000 gpm through the 6-inch hose exceeds the bursting strength.

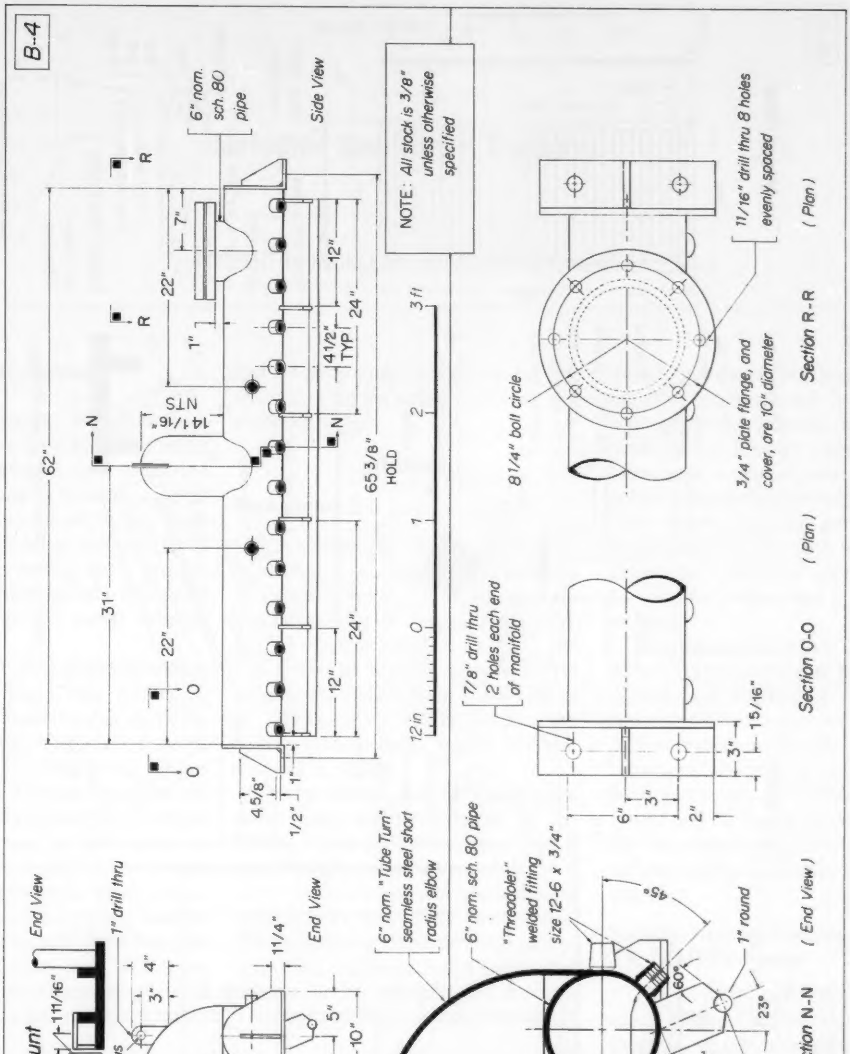
Appendix B


B-1
Top bars removed this side for clarity
a. Towing Eye (dwg. B-5)
b. Manifold Mount (dwg. B-4)
c. Hinged Panel (dwg. B-5)
d. Padeye (dwg. B-5)
65 3/8" Hold
24 1/2" radius
6" radius
24" radius
5" TYP
25°
198"
86"
Feet

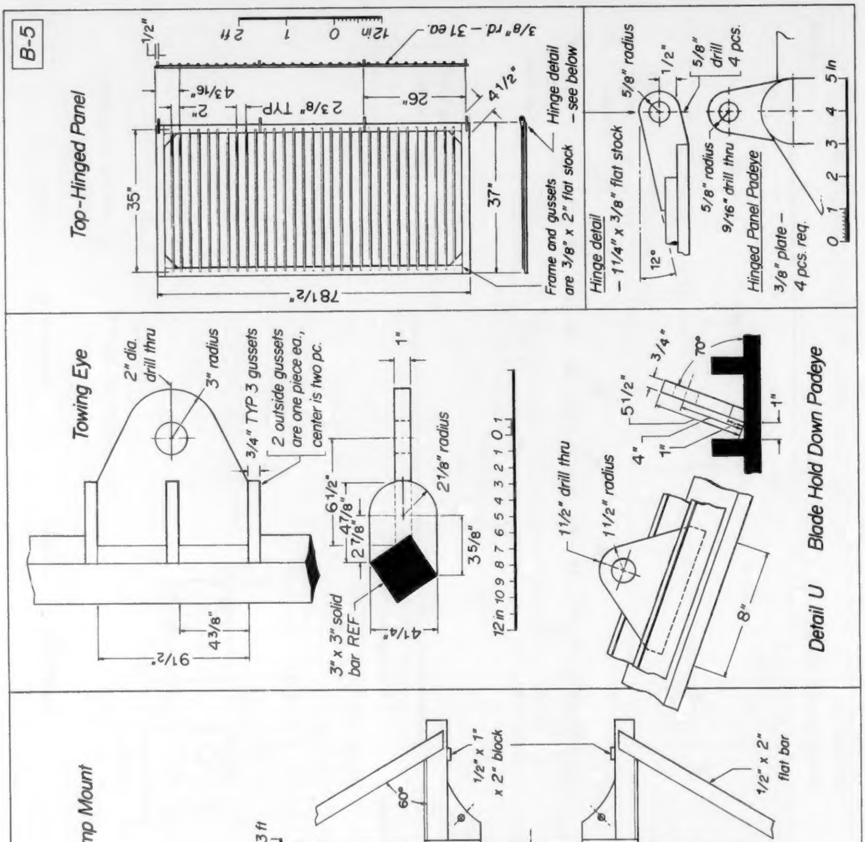

B-2
T Pump Mount
(dwg. B-5)
3" x 3" solid bar
S
1/2" bash plate
Section A-A
G (dwg. B-4)
U (dwg. B-5)
K
2" solid rd.
1 1/2" solid rd.
1" solid sq.
2" solid sq.
Details I, J, K (enlarged view)
a = 15/8"
b = 13/4"
c = 3"
d = 1/4"
e = 2"
f = 31/4"
g = 3/4"
h = 15/16"
i = 31/8"
j = 23/4"
k = 31/2"
l = 3"
m = 71/2"
11/4" nom. sch. 80 pipe, 2" lg. 10 req.
11/4" solid rd. 72" long, 2 req.
inches
Detail K Blade Hinge Mount (3/8" plate)
Door Release Pads
(trash)
(catch)
Detail I Trash Door Hinge
Detail J
3/4" x 2" plate TYP
release levers
side
plan
end
Views E-E Catch Door
21/2" nom. sch. 80 pipe, 4" lg. 2 pcs. req.
3/4" solid rounds spaced 11/2" between
1" x 3" solid flat
1/2" x 11/2" solid flat
Section C-C
1" x 2" solid flats
Feet
3/4" solid rounds spaced 2" between (diagonally measured)
Section D-D
1/4" plate
1" x 12" solid flat
View B-B Trash Door
5/8" solid rounds spaced 2" between
1/2" plate



B-3
4" x 5.4#/ft channel
1" nom. sch. 40 pipe 2 pcs. 10" long
Side members are 1/2" x 4" flat stock
9/16" drill thru 2 holes in each of 4 uprights.
3/8" plate gusset TYP
1/2" x 1/2" bar
1" x 1/2" flat bar
2" x 1/2" flat bar
2" rd. stock
Section L-L
Note: Blade is 1/2" x 3" single bevel flat blade steel
1" x 3" Flat stock
59 1/2"
3 1/2" TYP
5/8" rd. stock
1 1/2" REF
4 vertical members are 1"x4" flat stock
Do not weld in these corners
3 pc. stops fabricated from 3/8" plate
Blade Frame
60" Blade
Blade Frame (portion)
Section P-P
Washer from 3/8" plate 1 3/4" O.D., 1" I.D.
1" radius
1 1/4" drill through
1 1/4" nom. sch. 80 pipe
Section M-M (enlarged view)



B-4
Manifold Mount
DETAIL G
Side View
End View
spacers
13/16" drill thru 5 holes
1" drill thru
1" radius
65/8" REF
End View
53/4" O.D. rd. mechanical tubing .120 wall th.
6" nom. "Tube Turn" seamless steel short radius elbow
6" nom. sch. 80 pipe
"Threadolet" welded fitting size 12-6 x 3/4"
1" round
NOTE: Add 43/4" straight 6" nom. pipe extension
1" dia. drill thru for each of 16 "Threadolets"
inches
Section N-N
(End View)
6" nom. sch. 80 pipe
Side View
NTS
65 3/8" HOLD
41/2" TYP
NOTE: All stock is 3/8" unless otherwise specified
7/8" drill thru 2 holes each end of manifold
Section O-O
(Plan)
81/4" bolt circle
3/4" plate flange, and cover, are 10" diameter
11/16" drill thru 8 holes evenly spaced
Section R-R
(Plan)


B-5
Top-Hinged Panel
Frame and gussets are 3/8" x 2" flat stock
Hinge detail – see below
3/8" rd. – 31 ea.
Hinge detail – 11/4" x 3/8" flat stock
5/8" radius
5/8" drill 4 pcs.
5/8" radius
9/16" drill thru
Hinged Panel Padeye
3/8" plate – 4 pcs. req.
Towing Eye
2" dia. drill thru
3" radius
3/4" TYP 3 gussets
2 outside gussets are one piece ea., center is two pc.
3" x 3" solid bar REF
21/8" radius
11/2" drill thru
11/2" radius
Detail U
Blade Hold Down Padeye
Pump Mount
1/2" bash plate REF
1 x 3 REF
Side supports are welded to top of aft 1 x 3
1/2" x 1" x 2" block
1/2" x 2" flat bar
3/4" plate
1/2" plate
4 x 13.8 #/ ft
Drill thru 4 holes
3/4" plate

Satellite Sea Turtle Tracking

ROBERT E. TIMKO and A. LAWRENCE KOLZ

Introduction

For years, marine biologists have aspired to develop a means of recording the daily movements and migration routes of far-ranging animals such as the various species of sea turtles. Such knowledge would define preferred turtle habitats, locate nesting sites, provide foraging and behavioral data, and direct administrators toward sound management decisions.

Historically, marine turtles have been tracked with flipper tags (Caldwell, 1962), tethered floats (Carr et al., 1974), balloons (Carr, 1962), and radio beacons (Carr et al., 1972). Flipper tag returns rely on the chance returns by others and make a study very unreliable. Tethered floats and balloons are extremely expensive for they require a continuous support vessel to maintain visual contact, and they are restricted to fair-weather operation. Tracking with radio beacons, also costly, has been done with some success, but the experiments were limited to short duration and restricted range. Our research study provides an alternative: Tracking sea turtles with a satellite receiving system.

Methods

Background

The feasibility of tracking wild animals by satellite was originally demonstrated by Craighead et al. (1972), when an elk was tracked for 28 days with the NIMBUS 3 weather satellite. In 1977, the U.S. Fish and Wildlife Service (FWS) successfully tracked polar bears (Kolz et al., 1980) using the NIMBUS 6/Random Access Measurement System (RAMS) (Cote et al., 1973).

The transmitter used for tracking the polar bears was constructed by the Handar Company[1], Santa Clara, Calif. It consisted of a transmitter module (14 × 14 × 5 cm) and a 5 kg plastic attachment collar which contained the battery pack. The module contained the temperature-controlled oscillator, radio transmitter circuits, timing controls, and antenna. The coplanar antenna was contained in the lid of the transmitter module. Lithium batteries encapsulated in the collar served as the power supply with sufficient capacity for 1 year's operation. The instrument was designed to transmit pulses to the satellite for an 8-hour period every fourth day. This low-duty cycle was necessary to conserve the batteries, extend the transmitter operating life to 1 year, and reduce the total package weight.

This transmitter-collar unit was attached to a polar bear near Point Barrow, Alaska, and tracked by the satellite system for 390 days and over 1,000 miles. Although there are drastic physical and behavioral differences between polar bears and turtles, the NIMBUS satellite system and the hardware developed for the bear transmitter offered an approach which could be adapted for marine turtle tracking.

Satellite Tracking Equipment: The NIMBUS System

The NIMBUS 6/RAMS satellite system is a data collection and transmitter location system designed to collect meteorological and oceanographic data transmitted from randomly located mobile transmitters. The system is capable of handling the random transmissions for 200 transmitters within its field of view with a maximum of eight signals occurring simultaneously. The satellite storage capacity allows for 1,000 transmitters worldwide.

Data are transmitted to the satellite as 401.2 MHz radio frequency (rf) pulses. These pulses have a duration of about 1 second and occur at a rate of approximately one pulse per minute. Each pulse

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[1]Mention of trade names or commercial firms does not imply endorsement by the National Marine Fisheries Service, NOAA.

ABSTRACT—A female loggerhead sea turtle, Caretta caretta, *weighing 96 kg was instrumented with a buoyant cylindrical radio transmitter developed jointly by the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. The transmitter was attached to the rear edge of the turtle's carapace with a nylon tether, and the turtle was tracked by the NIMBUS 6 satellite system for 8 months during 1979 and 1980. The turtle was released about 20 miles off Mississippi into the Gulf of Mexico and traveled west and south to within a few miles of Brownsville, Tex. The total tracking distance exceeded 1,400 miles.*

contains a period of unmodulated carrier and a phase-modulated section for data synchronization, transmitter identification, and sensor data (if included). The unmodulated portion of rf carrier is used to measure the doppler frequency shift and calculate the latitude and longitude of the transmitter. The system is capable of determining a position to within ±5 km. This accuracy is a function of the number of messages received by the satellite in a given orbit. A minimum of four messages per orbit must be received in order for a position to be computed.

Preliminary Technical Considerations

The National Marine Fisheries Service (NMFS) and the FWS agreed to modify the hardware developed for polar bear satellite tracking into an instrument package suitable for attaching to a large sea turtle. Technical questions concerned the quality of signal that could be transmitted from a coplanar antenna floating directly on the ocean's surface because of possible signal distortions caused by surface reflections. Therefore, one test objective was to prove the feasibility for satellite tracking under these conditions.

Although the transmitter module for the polar bear was not of optimum size or shape, it was both expedient and economical to repackage for marine use. We therefore considered various enclosures for housing this basic module with an appropriate battery pack. The problem of attaching any package to a turtle was of real concern. Little is known about marine turtles, so the following guidelines were used.

1) The enclosure had to be watertight and capable of withstanding external water pressure. We arbitrarily selected a design specification of 200 pounds per square inch (psi) since no scientific data existed on expected pressure.

2) Radio signals could not be sent to the satellite from underwater. Therefore, the transmitter design had to maximize antenna exposure.

3) The package had to be smooth with no sharp edges or protrusions which could snag or catch on marine growths or other obstructions.

4) The package had to be constructed of low-loss dielectric material to allow radio signals to penetrate.

5) The package should have a small cross-sectional area to minimize drag and have minimal effect on a turtle's normal activity.

After considering these restraints, we concluded that a small cylinder towed by a lanyard offered the best solution in terms of available materials, strength, and simplicity. Prior research discouraged attachment of a rigid package directly to the turtle's carapace since turtles frequently surface with only their heads exposed. Therefore, the towed cylinder offered increased antenna exposure time and greater probability of reception. A cylinder 25 cm long and 15 cm in diameter was calculated to satisfy our requirements for weight versus flotation volume.

Captive Behavioral Studies

We intended to develop a package that would not substantially interfere with a turtle's normal behavior, and we devised tests to evaluate the degree of interference (obviously there would be some). Therefore, a cylindrical model of a transmitter was constructed, using plastic pipe fittings. The complete cylinder weighed 3.1 kg in air and floated 40 percent exposed or approximately 1.8 kg positively buoyant. This model was fastened by a nylon tether to the rear edge of the carapace of a 91 kg loggerhead turtle, which was the minimum size turtle considered for this tracking experiment. The turtle was released into a large aquarium at Marine Life Park, Gulfport, Miss., and observed for any abnormal behavior. Aside from some initial problems with the attachment method, no significant problems were observed. However, we decided to use a more precise evaluation method.

A cylindrical recording device (6.4 cm in diameter and 7.6 cm long) was then developed by the FWS electronics staff to quantify the surface behavior of a sea turtle. This recorder sensed the electrical resistance between two external electrodes that were either exposed to air as the cylinder floated on the surface or surrounded by conductive seawater when the turtle sounded. Electronic components tallied each time the electrodes were exposed to air, as well as data on the cumulative time the cylinder floated on the surface. We hypothesized that surface time would be one of the most effective measures to monitor the turtle's behavioral responses to the added buoyancy of the satellite transmitter package. We assumed that the small size of the recording device would have negligible effects on a large turtle.

Two 3-day rests were conducted at the Marine Life Park with the recording device: First, with only the small recording cylinder attached to the 91 kg sea turtle, and then with both the transmitter model and recording cylinder attached. The results indicate the turtle decreased the "number of surfacing" times from 5,357 to 3,489 and increased its total surface time from 16.5 percent to 29.7 percent when the transmitter model was attached. These absolute surfacing counts are suspect because of errors caused by wave action, but the percentage of surface time is considered quite accurate. We concluded that the transmitter package caused the turtle to spend about twice as much time at the surface.

We recognize that sea turtles in the wild may react differently, but this test seems to indicate that the turtle adapted to the added buoyancy without radical behavioral change. Within our limited time, we could conceive of no other simple test to provide a better indication of the turtle's adaptation to the transmitter.

Prototype Transmitter

Structural Tests

Once assured that a large turtle could reasonably tolerate our transmitter package, we began to develop a strong structural design. Heavier PVC plastic pipe components than those used for the behavioral test model were obtained for destructive testing. This new model consisted of two pipe caps and a 10 cm length of 15 cm diameter plastic pipe. The end caps were PVC cemented to the pipe and then "welded" together, using a process in which a PVC filler rod is actually melted into the base material with a heat gun similar to metal welding. A T-shaped bracket made of 0.6 cm PVC flat stock was also welded to one of the end caps as an attachment point for the towing lanyard.

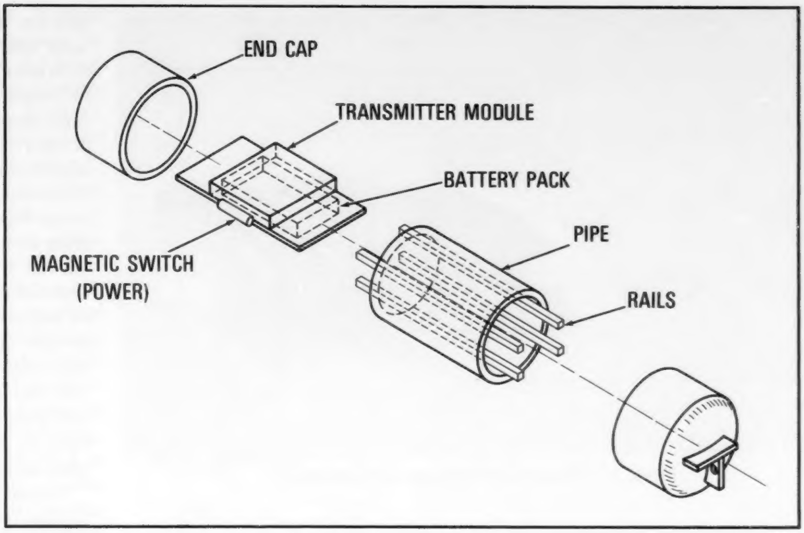

Figure 1.—Transmitter construction details.

This assembly was subjected to a hydrostatic pressure test and mechanical tension test. For the pressure test, the assembly was placed in a hydrostatic test vessel and subjected to increasing pressure until the end caps deformed at a pressure of 200 psi (equivalent to about 122 m depth). While this did not cause any internal leaks, we decided to regard this as the operational depth limit.

The mechanical tension test determined the strength of the attachment bracket. The transmitter model was secured in a test fixture and a shackle was attached to the bracket through an 0.6 cm hole. Increasing tension was applied to the bracket with a hydraulic test apparatus until the shackle was torn from the bracket. This occurred at a tension of approximately 264 kg which was far in excess of our requirements.

Construction Details

The construction details of the actual transmitter prototype are shown in Figure 1. All of the electronic components are attached to the 0.5 cm flat PVC plate. This plate was guided into the pipe by the mounting rails and was held in position with epoxy. Weight and balance were carefully checked to assure that the coplanar antenna surface floated level in the water. The center of gravity for the package was adjusted by positioning the five organic lithium batteries (Mallory Battery Company Type LO 26), which were mounted under the transmitter module. This was sufficient to power the unit at the original timing cycle for a 1-year period. The completed package was sealed in exactly the same manner as the test unit.

Two magnetically operated reed switches provided the on/off control and timer circuit initialization without the need for access inside the transmitter package. One switch applied power to all the electronic circuits while the second switch initialized the basic 4-day timer. The transmitter module also contained a secondary radio beacon which continuously radiated 165 MHz rf pulses at a peak power level of −10 dBM. This full-time tracking transmitter operated independently of the satellite transmitter and allowed the turtle to be located at any time by search aircraft.

Final Preparations

Functional Transmitter Tests

The completed transmitter was thoroughly tested for compatibility with the NIMBUS system by using two independent signal reception modes: The spacecraft system and the Local User Terminal (LUT) (Schmid and Lynn, 1978) at NASA's Goddard Spaceflight Center. Actual conditions were simulated for these tests by floating the activated transmitter in a pool of seawater. Both receiving systems provided positive tracking data, and these results completed our testing program for the transmitter package.

The Captive Turtle

A 96 kg female loggerhead turtle was obtained from a Mississippi shrimp boat captain before the final hardware tests. This turtle, nicknamed "Dianne," was captured off Mississippi's barrier islands and placed in a reef tank aquarium at Marine Life Park. The completed transmitter was now attached to Dianne and

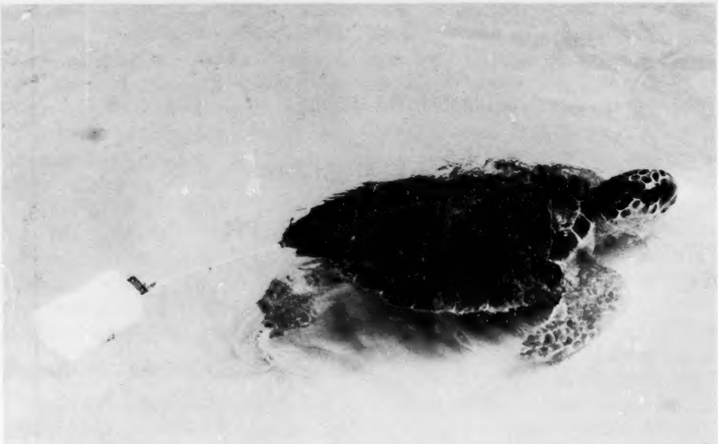

Figure 2.—Dianne swims with attached transmitter.

she was released into an outdoor pond for observation (Fig. 2), where she seemed oblivious to the attached transmitter.

The Release

Intense shrimping activity prevented Dianne's return to her capture site. Therefore, Dianne was released farther offshore into the Gulf of Mexico (lat. 30°5'N, long. 88°46'W) at 1230 hours on 16 October 1979. This position is about 20 miles south-southeast of Biloxi, Miss. As soon as the turtle was overboard, both visual and radio contact were lost for the rest of the day.

Tracking

During the entire experiment, there were three sources of position for the animal: Aircraft, spacecraft, and LUT (Schmid and Lynn, 1978). The aircraft tracking was accomplished using a chartered, fixed-wing aircraft equipped with directional wing-mounted antennas. Position fixes were obtained using standard radio direction finding (RDF) techniques and an onboard loran-C receiver.

Two types of satellite fixes were available. The first type, the spacecraft system, used the following approach. The transmitter data were collected by the spacecraft during an entire orbit and were recorded on an onboard tape recorder. This information was telemetered to a ground station at Fairbanks, Alaska, and was subsequently relayed to the Goddard Spaceflight Center for computer processing. Position fixes were then available on computer tab forms after approximately 1 week.

The second type of satellite fix was available from the LUT, which is a real-time system and uses the satellite as a transponder (receiver/retransmitter). The transmitter data are reflected by the satellite to the LUT at Goddard which, using the self-contained minicomputer, calculates the platform position. Data are available by phone within 2-4 hours after satellite overpass.

Results and Discussion

The days immediately following the release were thought to be critical in terms of the operation of the transmitter, as well as Dianne's acceptance of it. Thus, we felt special concern when few radio transmissions to the satellite were received. Table 1 summarizes the dates Dianne was located by the three tracking systems: Aircraft tracking, NASA's LUT, or the spacecraft. As indicated, only five satellite positions were obtained during the last 2.5 months of 1979. Dianne's position was determined from aircraft three times in October and three times in November. There was great concern in November when no satellite receptions were obtained. Then, for unexplained reasons, good satellite tracking information began in January 1980 and recorded until 15 June, when the transmitter was recovered from the beach 30 miles west of Port Arthur, Tex. During the full 8-month period, satellite fixes were obtained on 35 days out of 60 days on which the transmitter operated (58 percent successful). Dianne's position was obtained during the same day by both the spacecraft and the LUT on only three occasions, so the two systems seem to complement each other with minimal duplication.

Dianne's migratory route across the northwestern Gulf of Mexico is charted in Figure 3. She remained in the vicinity of Chandeleur and Breton Islands during October and November. In mid-December, she moved southward around the mouth of the Mississippi River and then westward approximately following the 10-fathom depth contour into Texas waters. She paused briefly offshore from Galveston during late January or early February. On 11 February, with the aid of a U.S. Coast Guard helicopter, visual contact was made with Dianne and photographs were taken of the turtle with the attached transmitter (Fig. 4).

Dianne continued her track southward to an area off Corpus Christi, Tex., where she remained from mid-February to mid-April. Her southernmost location was within about 30 miles of Brownsville, Tex. After April, she began to move

Table 1.—Dates on which loggerhead turtle "Dianne" was located by the three tracking systems.

Date	Aircraft	LUT	Spacecraft
1979			
October	17, 18, 25	20, 28	24
November	5, 15, 29		
December			15, 31
1980			
January		12, 28	4, 12, 16, 24
February	1, 11	1, 5, 13, 17, 21, 29	1, 9, 21
March		8, 20, 24, 28	12, 16
April		1, 5, 13	17, 21, 29
May		7, 23	19, 31
June			4, 8

northeast to a position about 10 miles off Port Arthur, Tex. Two consecutive satellite fixes indicated that the transmitter was on the beach about 30 miles west of Port Arthur. After a 1½-week period, during which no positions were obtained, we began to receive data indicating that the transmitter had moved inland approximately 500 miles to a small town named Galena, Kan. It was later learned that the transmitter had been found on the Texas beach by a man vacationing there. He had returned home to Kansas with the transmitter and later returned it to us with the report that the attaching lanyard had "obviously been cut" and there was no indication what might have happened to the turtle.

The transmitter was photographed on return and is shown in Figure 5. The braided lanyard had unravelled by this time, but the transmitter was otherwise in perfect operating condition.

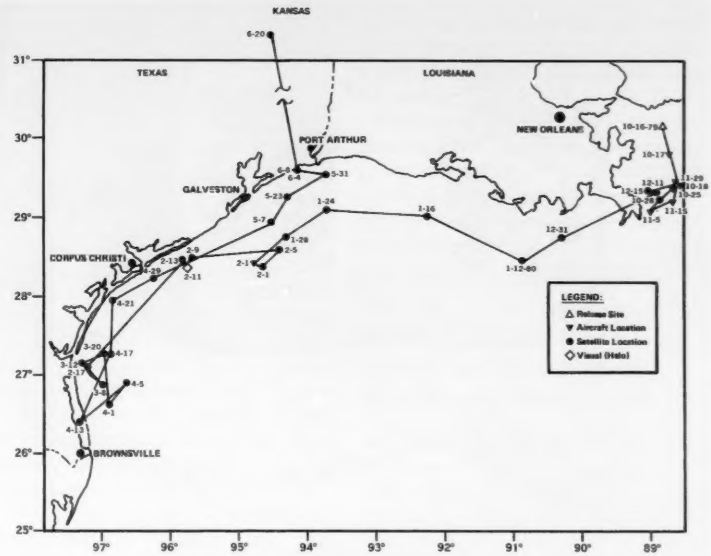

Figure 3.—Dianne's track in the Gulf of Mexico.

Figure 4.—Dianne as photographed from the U.S. Coast Guard helicopter.

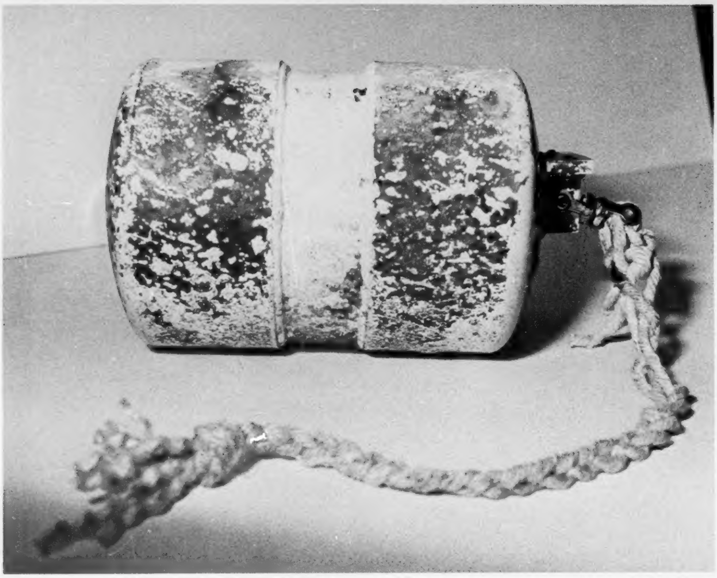

Figure 5.—Dianne's recovered transmitter.

Conclusions

The proximity of the coplanar antenna to the surface of the water apparently did not distort or otherwise preclude adequate radio transmissions to the satellite. However, no explanations are available for the lack of satellite messages during 1979, other than the turtle's activity and sea state. There was turbulent, windy weather during this period which could have caused the transmitter to be awash and thereby interfere with radio transmissions, but the turtle was obviously at the surface part of the time because she was located from tracking aircraft.

We can offer no explanation as to why the spacecraft and the LUT receiving systems seldom provided location data on the same days. In fact, "same-day" fixes from both systems occurred only 9 percent of the time. A total of 19 positions were obtained by the spacecraft and 18 by the LUT. In summarizing the data, we find no apparent correlation between the reception time of day, number of received messages per satellite pass, or the number of successively received pulses. These data can be made available to researchers upon request.

The success of this turtle tracking experiment should provide an impetus for researchers to develop satellite-compatible electronics for other marine life. The obvious design problems for many sea animals are that they spend little time near the surface, the timing for the transmitted signals will be critical, and it will take creative engineering to develop suitable transmitting antennas and attachment methods. Certainly we would project that the development of satellite tracking equipment for marine research will require a significant investment in money and manpower.

Acknowledgments

We wish to acknowledge the cooperation of Thomas Moore and Gene Gilbert of NASA-Goddard for their very valuable assistance throughout the tracking experiment.

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New Gear Damage Rules Announced

William Gordon, Assistant Administrator for Fisheries of the National Oceanic and Atmospheric Administration (NOAA), has announced the publication of final regulations implementing legislative changes in the Fishing Vessel and Gear Damage Compensation Fund program.

This program, authorized by section 10 of the Fishermen's Protective Act, compensates U.S. fishermen for fishing vessel and gear casualties which are caused by other vessels. The American Fisheries Promotion Act, enacted 22 December 1980, amended the section 10 program by 1) compensating for 25 percent of gross income that a fisherman loses as a result of a casualty; 2) providing fishermen with a presumption that unobserved gear casualties are caused by other vessels (this presumption may be challenged by the Government); and 3) eliminating the eligibility of casualties caused by weather and sea conditions.

The economic loss resulting from a gear or vessel casualty is based on the receipts or trip tickets fishermen receive with payment of their catch. It is computed in three stages.

First, the agency compensates for the income lost at the time a fisherman discovers a casualty. This loss is computed by averaging the income per unit of gear for the three trips before that of the casualty, multiplying this average times the number of gear units lost, and computing 25 percent of the result.

Second, the agency compensates for the income lost on the vessel trip immediately after the casualty if the gear could not be replaced beforehand. In most instances, it cannot be. So fishermen will lose income on the next trip after the casualty even if they have reserve gear on shore ready to be deployed. The agency bases the income lost on this trip on the average income per unit of gear for the trip. If the fisherman was unable to make this trip because so much gear was lost that the trip was not economically feasible, the economic loss will be considered the same as for the trip of the casualty.

Finally, the agency compensates for the income lost on other vessel trips made between the time replacement gear is ordered and received or repair begun and completed. The amount of this compensation is based on the average catch value of each unit of gear being used on these trips. If no trips could be made because of the extent of the loss, trip tickets for trips made the previous year during the same period will be used to determine the amount of compensable loss.

The requirement to order the replacement or repair of gear as a condition for receiving compensation for lost income, Gordon explained, was necessary to protect the Fund from possible abuse. "We could not allow the Fund to pay for the lost income of anyone who does not make a good faith effort to restore the lost or damaged gear as quickly as possible," he said.

Gordon said it was necessary to find a reasonable basis for challenging the presumption that an unobserved casualty was caused by another vessel rather than some ineligible cause such as weather.

"Since most fixed gear casualties are caused by vessels operating mobile gear," Gordon continued, "we looked to see what kind of weather conditions would be too severe for mobile gear operations and found that weather with winds of 48 knots or more generally stops even the big draggers. If we receive a claim and find that the weather at the time of the loss was too severe for the trawlers to operate, then the most probable cause of the casualty was the weather."

Gordon said that the agency has application forms available for filing claims under section 10. These forms and copies of the new program regulations can be obtained by writing the Financial Services Division, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Fishermen's Contingency Fund Regulations Issued

Interim regulations designed to reduce the time required to process fishermen's claims for damage or loss of fishing gear caused by underwater obstructions associated with oil and gas exploration and production activities on the Federal Outer Continental Shelf have been issued by the National Oceanic and Atmospheric Administration (NOAA).

William Gordon, NOAA's Assistant Administrator for Fisheries, said that the Interim rulemaking, published 8 December under the Fishermen's Contingency Fund, will reduce processing time of claims by as much as 3½ months. Under the previous rules, claims required from 6½ to 10½ months to process. The principal cause of the long processing time was the regulatory requirements for extensive review by the Financial Services Division of the National Marine Fisheries Service and the NOAA General Counsel's Office, according to Gordon.

"We've eliminated duplications in the processing procedures," Gordon said. "Under the interim rulemaking, we at Fisheries will coordinate the issuance of public notices and make an effort to collect from applicants all information needed to complete a claim. Then we will forward the claim to an administrative law judge for his decision."

The reason that the rulemaking was established on an interim basis, according to Gordon, is that legislation is pending in Congress to streamline the program to an even greater degree than is possible through the regulatory process.

"This is not the perfect solution," Gordon said, "But it is certainly an im-

provement on the old method."

Gordon said that if the bill to amend the program is passed, the agency will be able to process claims within 30-60 days. The pending legislation, according to Gordon, will make the Fishermen's Contingency Fund program very similar to the Fishing Vessel and Gear Damage Compensation Fund program, authorized by section 10 of the Fishermen's Protective Act.

The section 10 program, Gordon said, was enacted by Congress on the same date as the Fishermen's Contingency Fund, 18 September 1978. Since enactment 62 claims have been processed in the Fishermen's Contingency Fund program. Of these, 23 were approved for payment of $94,048.96. Under the section 10 program, the agency has processed 882 claims, of which 825 were approved for payment of $5.8 million. The average processing time on completed section 10 claims has been about 56 days.

Since the two programs have been administered out of the same office, Gordon attributed differences in performance to the differences in the authorizing laws and in the rules implementing the programs.

Gordon said that the agency has application forms available for filing claims against the Fishermen's Contingency Fund. These forms and copies of the new program regulations may be obtained by writing the Financial Services Division, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Foreign Fishery Developments

The Fisheries of Trinidad and Tobago

Background

Trinidad and Tobago imported 131 t of fishery products from the United States in 1980. more than double the 64 t imported in 1979, according to the NMFS Foreign Fisheries Analysis Division. The most important commodity imported was canned salmon. Some observers believe that imports from the United States could be increased, for the current fishery import market is dominated by the United Kingdom and Canada.

The U.S. Regional Fisheries Attache for Latin America, Charles E. Finan, visited Trinidad and Tobago last year to review the status of the fisheries and investigate the possibility of increasing exports of U.S. fisheries products. While data on fish productivity is somewhat rough and subjective, there is detailed information on fish product imports and exports. Here, data has been gathered from official sources, knowledgeable observers, and the FAO for the reader's comparison.

According to the Fisheries Division of the Ministry of Agriculture, Lands and Fisheries, 1980 fisheries production was on the order of 25 million pounds, with Spanish mackerel constituting about half the catch. The Division put production of shrimp at 2 million pounds, and estimated lobster production at about 1 t, a marginal industry except to sport divers. Kingfish production was reported to have been 2 million pounds, shark 3 million pounds, red snapper over 1 million pounds, with one-half million pounds of flying fish caught, mostly for export to Barbados.

The FAO Fishery Country Profile shows the 1978 production as some 16,600,000 pounds live weight, so a 25,000,000-pound production in 1980 is quite a respectable increase. However, as indicated later, that 1980 figure may have been overly conservative.

It may also be well to compare the above data to data in Table 1, the total wholesale distribution reported. According to that data from the Central Statistical Office, in 1979 some 2,546,000 kg were reported distributed throughout the country, of which 1,016,000 were carite and kingfish and 1,202,000 were mostly shark and shrimp. Export data for the same year show that 207,000 kg were exported. (By contrast, according to the Central Statistical Office, 3,600,000 kg were imported that same year.) Clearly, whatever the level of production, it is not keeping up with what is described as one of the highest per capita demands for fish in the world. More details on exports and imports are shown in Tables 2 and 3.

The Division notes that imports are

Table 1.—Fish sold at Port of Spain and San Fernando markets by quantity and value.

Year and period	Total		Carite and kingfish		Herring		Cavalli		Redfish		Other types[1]	
	1,000 kg	TT$1,000[2]	1,000 kg	TT$1,000	1,000 kg	TT$1,000	1,000 kg	TT$1,000	1,000 kg	TT$1,000	1,000 kg	TT$1,000
1974	2,721	4,417	514	1,331	144	66	224	482	117	317	1,721	2,220
1975	3,012	5,038	1,091	2,199	178	85	156	329	101	295	1,485	2,130
1976	2,726	5,603	768	2,170	154	80	168	481	88	310	1,548	2,562
1977	3,162	6,826	1,116	3,142	116	52	231	525	122	408	1,577	2,697
1978	2,944	8,443	1,065	3,836	153	81	204	628	155	712	1,369	3,187
1979	2,546	9,468	1,016	4,441	83	99	138	576	107	599	1,202	3,754
1978 1st quarter	690	2,009	135	616	11	8	42	158	35	175	467	1,052
2d quarter	713	2,198	202	932	47	25	49	155	41	203	374	882
3d quarter	770	2,190	341	1,174	57	27	62	185	48	196	263	608
4th quarter	771	2,046	387	1,114	38	21	51	130	31	138	265	645
1979 1st quarter	622	2,305	80	527	16	18	29	142	35	208	462	1,409
2d quarter	683	2,469	308	1,206	13	17	43	174	24	130	295	941
3d quarter	640	2,402	345	1,477	29	35	30	113	25	135	211	642
4th quarter	601	2,292	283	1,229	25	29	36	147	23	126	234	762

[1]Includes inter alia shark and shrimp.
[2]US$1.00=TT$2.40 as of 17 July 1981.
Source: Ministry of Agriculture, Fisheries Division.

indeed going up. Particularly important are salmon, canned sardines and herring, mackerel, smoked and pickled cod, and alewives. Most of this is from the United Kingdom and Canada, but frozen shrimp, canned mackerel, sardines, and salmon are imported from the United States. Total 1980 imports were estimated by the Division as about 10 million pounds. The Division described import duties as negligible, and said there are no price controls on fish sold at wholesale or retail. Therefore, imported fish have no built-in liability on the local market.

The Fleet

According to the Division, fishing has become a very profitable trade, and more vessels are being added to the fleet every year. Again from the FAO 1980 Profile, there were 2,133 registered fishing vessels in 1977. With over 200 vessels being registered each year, even allowing for boats sunk, burned, scrapped, sold or whatever, a steady fleet growth is indicated.

The Trinidad artisanal fleet consists of "pirogues" of 24-31 feet. The Tobago fleet of pirogues is smaller, normally 16-22 feet. Power is normally by 40-65 horsepower outboard motors. There are no sailboats.

The National Fisheries Co. (NFC), a government corporation now under private management, has 21 shrimp trawlers, each of 75 feet with freezing capabilities, now working waters off Surinam and Guyana. Brazil had closed off shrimp fishing to the Trinidad and Tobago fleet for the time being, but Trinidad and Tobago officials hoped that this fishery could again be opened. Seven Korean tuna longliners under contract to the NFC were fishing for tuna in the vicinity of long. 40°W and lat. 5°N. Four more of these 300-t vessels were scheduled to join the fleet. The fleet includes three 90-foot trawlers and one of 170 feet.

Table 2.—Trinidad and Tobago's fishery imports and exports, 1979.

Commodity	Total imports C.I.F.		Total exports F.O.B.	
	Quantity (kg)	Value (TT$[1])	Quantity (kg)	Value (TT$[1])
Fish: fresh chilled frozen	N/A[2]	95,033	N/A	1,412,684
Fish: canned	1,939,856	9,436,976	11,689	34,901
Crustaceans and mollusks	27,417	365,484	181,133	1,087,336
Fish, crust., & moll. prep.	1,610,900	8,458,546	14,038	44,609

[1]US$1.00 = TT$2.40 as of 17 July 1981.
[2]N/A = Not available.
Source: Ministry of Agriculture, Fisheries Division.

The NFC reports that maintenance of larger vessels is quite costly, and that the cost of a typical 75-foot shrimp trawler is US $400,000. A typical shrimper has four crewmen. Fuel costs TT $45 (the bank rate is TT $2.40 to US $1.00) per metric ton, a special, subsidized price. A fisherman on a shrimp boat gets paid by the voyage. On the average he works about 6 hours a day and a typical voyage is 3 weeks. The NFC is not interested in buying boats at this time, but is most interested in joint ventures involving access to other nations' fishing grounds.

Table 3.—Trinidad and Tobago imports and exports fish and fish products, 1970-78.

Year	Imports		Exports	
	Quantity (Pounds)	Value (TT$[1])	Quantity (Pounds)	Value (TT$[1])
1970	7,348,653	$4,859,078	5,691,640	$4,560,842
1971	6,576,923	5,072,587	2,158,885	1,975,260
1972	7,275,411	6,094,089	1,121,984	1,611,186
1973	5,828,674	5,485,898	4,251,201	3,974,271
1974	6,785,682	9,206,224	2,794,801	2,335,406
1975	6,596,912	9,662,763	1,704,744	1,916,899
1976	7,584,134	12,527,453	3,654,186	2,733,127
1977	5,766,171	10,882,550	3,736,819	2,118,489
1978	10,342,026	18,223,705	1,104,550	1,735,979

[1]US$1.00=TT$2.40 as of 17 July 1981.
Source: Ministry of Agriculture, Fisheries Division.

National Fisheries Company

In 1973 the Trinidad and Tobago Government formed the NFC to carry out large-scale shrimp and finfishing operations and to engage in processing and marketing operations. Continuing financial and management difficulties led to the hiring 2 years ago of a private local management firm, Navarros and Company Ltd., to take over the NFC's affairs.

According to NFC officials, the company's objective for the first year was to produce 20 million pounds of various types of fishery products. Press accounts indicate the eventual goal is 50 million pounds annually. Present capacity for filleting 7,000 pounds of fish a day manually, using 32 people in 2 lines, will eventually be joined by 3 more filleting

lines employing 48 more people, a special line for preparing sharks, and a mechanized filleting machine capable of handling 6,000 pounds per hour.

NFC officials reported that their plant was already packing headless and peeled and head-on shrimp for shipping to the United States, meeting full U.S. size and sanitary standards. The NFC also formerly had a fishmeal plant in operation (it was then idle) and would soon add the capacity for battered and breaded products. Salting, drying, and smoking operations are also possible.

The NFC also handles imports of fish for domestic consumption, as well as purchases of fish from foreign fleets. Such imports include frozen, semiprocessed, block, and minced fish for fish cake. From 60 to 70 percent of imports are frozen; smaller proportions are dried, smoked, refrigerated salted, or otherwise processed.

The NFC invites all foreign fleets to collaborate in the supplying of fish products. Asked about interest in purchasing frozen U.S. underutilized species, NFC officials said the United States would be a welcome supplier if prices were more competitive. At the moment, they claimed to get better prices and quality by buying from Japan, Taiwan, and South American sources. The most popular imports are white fish, particularly hake, cod, and whiting. Trinidad and Tobago is also a good market for shrimp, NFC officials say, stating the price of shrimp in Port of Spain is higher than on world markets. Lobster tails, red snapper—whole and filleted—as well as kingfish, Spanish mackerel, and other mackerels are also highly saleable.

The NFC monitors Trinidad and Tobago catch data, and officials there believe the Fisheries Division's production data are highly conservative. They believe the overall catch may be closer to 30 or 40 million pounds of fish, rather than the 25 million cited by the Division. They see shrimp as close to 10 million pounds, and Spanish mackerel and lobster tails as double the Division's figures. (Incidentally, other sources agree the lobster figure is much too low.) NFC officials similarly believe that Trinidad and Tobago is catching much more red snapper, kingfish, and shark than the official figures would indicate. However, they agree that collection of accurate data is a basic need.

Also needed, NFC officials say, are up-to-date surveys of fish stocks; the last survey of available resources in the waters around the islands was done by the FAO about 8 years ago. (A related issue mentioned by various sources is the fact that Trinidad and Tobago has no laws specifically prohibiting fishing in its waters, and is still working on the declaration of an Exclusive Economic Zone.)

NFC officials say that a phenomenon of the oil-rich country is the steady increase in customers who want processed fish products. Of course some of this demand is at hotels and restaurants which cater to foreigners, but Trinidadians, also, are increasingly customers for such products.

The Import Picture

RFA Finan spoke in detail with officials of a major fish importing firm, which is importing live Maine lobster, lobster tails, king crab, clams, oysters, squid, and (from Taiwan) kingfish. This company utilizes air shipment exclusively and specializes in service to local restaurants, which pay a premium price for prompt, dependable service. Import problems include the difficulty of securing a reliable customs broker (an absolute necessity) and getting an import license promptly.

This firm said that as Trinidadian demand rises, so do prices of most fish. Maine lobster was running about US $14 per pound, and 26-30 shrimp were worth TT $12.00 per pound. Chinese restaurants are primary purchasers of shrimp. There are reportedly excellent opportunities for increasing exports of U.S. fish products to the islands. Squid and mackerel from the United States are highly attractive. There is good air cargo service from the United States, and local importers are used to air cargo procedures. Trinidad and Tobago has adequate frozen storage space, costing about TT $2.08 per pound per month. Interested parties need to survey not only fish importers, but also the individual hotels, which have their own brokers and do their own importing.

Finan had hoped to discuss the import situation with appropriate officials of the large Hi-Lo Supermarket chain, but its chief food buyer was not in the country. However, fish displayed on ice at one store was advertised as: White fish, TT $6.99 per pound; Salmon, TT $0.99 per pound; dark fish steaks, TT $4.59 per pound; and small peeled shrimp TT $8.99 per pound. Salt cod from Canada was priced at TT $4.99 per pound. By late afternoon, although there were plenty of packaged, processed fish items in that store, fresh-frozen supplies were very low. Of course, most fish was bought at the central market very early in the morning or from individuals selling around the city.

Hotel officials on the islands would apparently be delighted to talk to U.S. processors and exporters about increasing exports of fish. They cannot secure sufficient fish products for their clients as it is. There are at least 14 hotels on the two islands which have dining facilities.

Another possible opportunity to increase exports would be in U.S. species of aquarium fish. Trinidad and Tobago used to be a major exporter of aquarium fish to the United States, but, according to exporters, local species are being damaged by marine contamination. Trinidadians are now reportedly stocking their aquaria with goldfish stocks from the United States.

In the opinion of the Regional Fisheries Attache, Trinidad and Tobago should provide an opportunity to increase U.S. exports beyond the 1980 level of 290,150 pounds valued at $488,878. This nation of some 1,500,000 inhabitants lists a per capita income of over $1,900, and enjoys the income from an oil production of 201,000 barrels per day and gas production of 5.5 million m^3 per day. Given the continually increasing demand for a wide variety of fish species, Trinidad and Tobago would appear to be a potentially valuable export customer, despite increasing domestic catches.

Persons interested in communicating with potential importers will find contacts listed in IFR-77/262R (revised 31 March 1978) and IFR-81/117 at NMFS Market News Offices. (Source: IFR-81/117.)

Mexico Aims for Large and Modern Tuna Fleet

Mexico is building one of the world's largest and most modern tuna fleets. In early October 1981, Mexico had a fleet of about 60 tuna vessels. That country is currently building an additional 61 vessels for its tuna fleet; of these, 13 will be constructed in domestic and 48 in foreign shipyards. Of the latter total, 20 seiners were ordered in Spain, 10 longliners in Japan, 7 seiners in Italy, 5 seiners in the United States, 4 seiners in Canada, and 2 seiners in Norway.

All these vessels are scheduled for delivery by the end of 1982 when the Mexican Government estimates that its tuna fleet will have a total carrying capacity of about 110,000 t. Such a fleet will rival the U.S. tuna fleet which totaled 126 seiners with a carrying capacity of 105,000 t in 1980. Recent reports from Mexico, however, indicate that Mexican officials have begun to reevaluate the massive planned expansion of the country's tuna fleet. Unconfirmed reports suggest that some of the above vessel orders may be canceled as the Government has reportedly decided to limit the fleet to 100 purse seiners. In addition, some of the seiners transferred to Mexican flag will now reportedly be transferred back to U.S. registry. Thus, while the exact numbers are not available, it is clear that by late 1982 Mexico will have one of the world's major tuna fleets.

Mexico may have difficulty operating such a large, newly acquired tuna fleet economically within the 200-mile Exclusive Economic Zone (EEZ) which it claims. Even when tuna schools appear in large quantities off Mexico, the country probably will not be able to profitably deploy such a large fleet within its own 200-mile EEZ. The Mexican tuna fleet will have to be increasingly deployed in the 200-mile zones claimed by neighboring countries. The Mexican Department of Fisheries is planning for such distant-water operations and has begun to build modern tuna ports and canneries in southern Mexico at Puerto Madero near the Guatemalan border and at Salina Cruz. The Puerto Madero port will be operated by Mexico's state-owned fishing company, Productos Pesqueros Mexicanos (PPM), which has obtained loans from four Mexican Government agencies, Saudi Arabia, and Denmark to build the port.

This huge buildup of the Mexican tuna fleet will place an even greater stress on the already overfished tuna stocks in the Eastern Tropical Pacific (ETP). Yellowfin tuna yields and the average size of the fish caught in the ETP have been declining for several years. The 1980 yellowfin catch in the Inter-American Tropical Tuna Commission Convention Area was below the estimated maximum sustainable yield (MSY) of 160,000 t. The 1981 catch will probably also be below the MSY. The low 1980 and 1981 yellowfin catch of the entire international tuna fleet may be partly due to Mexico's exclusion of the U.S. tuna fleet from the Mexican 200-mile EEZ[1]. Nevertheless, it is generally believed that the yellowfin tuna is being overfished in the ETP. The Mexican 1981-82 fleet additions are the largest in the history of the ETP tuna fishery, and the impact of the increased fishing effort on tuna stocks is impossible to calculate.

Mexico is experiencing difficulties in unloading, processing, and storing its current tuna catch. The Government is expanding old and building new canning and freezing plants in various locations along its Pacific coast: Isla de Cedros, La Paz, Matancitas, Mazatlan, Salina Cruz, and Puerto Madero. It is unlikely that these facilities, however, will be capable of handling the catch of all the new vessels in the near future. The problem will be especially acute if Mexico and the United States do not resolve their dispute over tuna management policies so that Mexico can resume exporting frozen tuna to the United States. Plans for the development of the Mexican tuna industry were based on exporting to the United States, one of the world's most important tuna markets. A continuation of the U.S. embargo on Mexican tuna for a prolonged period will significantly affect Mexico's economic calculations. (Source: IFR-81/160.)

[1]The 1981 catch was also limited by problems the Mexican tuna fleet experienced. Mexico will report a sharply higher 1981 tuna catch, but the catch would have been even higher if the country's fleet had not lost fishing time as a result of delays unloading in Mexican ports and if the fleet had not been forced to reduce fishing effort because of the country's inability to sell existing stocks of tuna.

Japan Negotiates With Micronesia and Palau

In December 1981, the Japanese Government negotiated with the Federated States of Micronesia and the Republic of Palau for the permission to fish inside the 200-mile fishery jurisdiction claimed by these Pacific islands. Negotiations with the Micronesians temporarily ended in disagreement, while negotiations with Palau continued.

Federated States of Micronesia

Fishery negotiations between Japan and the Federated States of Micronesia[1] (FSM) broke off on 10 December 1981, according to a Japan Fisheries Agency official. The two parties met to extend the current private fisheries agreement (which was to expire on 31 December 1981) between the FSM and three Japanese fishery associations whose members fish within the Micronesian-claimed 200-mile zone. The two sides disagreed on the fishing fees and the method of payment and, as a result, negotiations were suspended. The FSM reportedly wanted to nearly double the 1981 Japanese fishing fee of about 2.3 million, while Japan wanted to change from paying an annual lump sum to paying a fee for each vessel. Japanese vessels were expected to stay out of the 200-mile zone which the FSM claims until agreement was reached. Both Japan and FSM planned to resume negotiations early this year.

[1]The FSM consists of the districts of Yap, Truk, Ponape, and Kosrae in the Caroline Islands.

Republic of Palau

Japanese fishing vessels reentered the Palau-claimed[2] 200-mile zone on 1 December 1981, after Palau's legislature ratified a provisional fisheries agreement with Japan on 2 October 1981. Under the 4-month agreement, Japanese fishermen were allowed to fish there until 31 March 1982. The Chairman of the Palau Maritime Authority, John Sugiyama, was scheduled to meet on 21 December 1981 in Tokyo with Japanese fishery officials to discuss the extension of the agreement beyond 31 March 1982. (Source: U.S. Regional Fisheries Attache, U.S. Embassy, Tokyo, IFR-81/188.)

[2]Palau is in the southwest region of the Caroline Islands.

Note: Unless otherwise credited, material in this section is from either the Foreign Fishery Information Releases (FFIR) compiled by Sunee C. Sonu, Foreign Reporting Branch, Fishery Development Division, Southwest Region, National Marine Fisheries Service, NOAA, Terminal Island, CA 90731, or the International Fishery Releases (IFR), Language Services Biweekly (LSB) reports, or Language Services News Briefs (LSNB) produced by the Office of International Fisheries Affairs, National Marine Fisheries Service, NOAA, Washington, DC 20235.

Egyptian Food Labeling Requirements Enforced

Egyptian authorities are increasing their enforcement of existing food labeling regulations, which in the past have not been strictly enforced, according to the U.S. Department of Agriculture. The Minister of Supply and Home Trade has announced that all imported packaged or canned items not conforming to Egyptian labeling requirements will not be cleared from customs. Violators (Egyptian importers, customs officials, etc.) will be jailed for 6-24 months and fined from $595 to 1,190.

Although labeling requirements differ from one product to another, in general each food consignment must be accompanied by a certificate of analysis, health certificate, and a certificate indicating that the product is used in the country of origin for human consumption.

Canada's Pacific Fishing: The Pearse Report

The Canadian Federal Government appointed University of British Columbia economist Peter Pearse to form a commission on Pacific fisheries in January 1981. He was charged to study and make recommendations on the condition, management, and utilization of fishery stocks on the Pacific coast of Canada. Since January, Pearse has conducted a one-man inquiry, and on 9 November he issued a 150-page preliminary report entitled "Conflict and Opportunity."

Pearse concludes that the fishing industry on the Canadian west coast is confronted with serious and fundamental problems. It is essentially a question of too many boats chasing too few fish. He recommends that the size of salmon and herring fleets be reduced. Pearse's preliminary report includes several concrete recommendations:

1) A major "buy-back" program of fishing boats largely financed by royalties and managed by a crown corporation. The program would close the loopholes left in a similar program launched 13 years ago by then Canadian Fisheries Minister Jack Davis.

2) Royalties on all landings of salmon and roe-herring beginning in 1982. The charges should be collected from those who buy fish from the fishermen.

3) Elimination of subsidies to Canadian shipyards for vessel construction or conversion and tighter restrictions on replacement of currently licensed vessels with new vessels having increased fishing power.

4) Elimination of tax subsidies for the purchase of new fishing vessels.

5) A new licensing system to license fishermen rather than vessels, which is the current practice.

6) Changes in rules governing transfers and designation of gear permitted under each licensee.

7) A quota system for halibut and food-herring fisheries that will provide each licensee with the right to harvest a predetermined quantity of fish.

8) Establishment of a native Indian fishing corporation administered by the Indians to ensure their survival within the commercial fishing field. (Source: U.S. Consulate General and IFR 81/172.)

Latin American Fish Group Is Organized

Fisheries ministers and directors from 10 Latin American countries met in Guayaquil, Ecuador, on 16 October 1981, to discuss a regional approach to fisheries problems. Delegations from Costa Rica, Chile, Cuba, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, and Peru attended the series of meetings held under the auspices of SELA (Sistema Económico Latinoamericano). Mexico's active delegation was headed by Fisheries Director Fernando Rafful. Observers from Brazil, Colombia, FAO, the Inter-American Development Bank, and other international bodies were also present.

The meeting began on 13 October with the arrival in Guyaquil of the staff from SELA's Action Committee on marine products. The Action Committee was created in 1977 only 2 years after the formation of SELA itself. The task of the Action Committee was to lay the groundwork for the arrival of the fisheries ministers on 16 October. The ministers met 16 and 17 October, reviewing the work of the Action Committee and attempting to arrive at a consensus on fishery issues. Several ministers pointed out the importance of marine food resources in the SELA area and their largely unexploited nature. At the same time, the speakers seemed fully cognizant that reckless and hasty exploitation of Latin America's marine resources could lead to rapid depletion.

The ministers concluded an agreement at the Action Committee's recommendation, establishing a permanent regional fisheries authority to be called OLDEPESCA (Organizacion Latinoamericano de Desarrollo Pesquero). OLDEPESCA will replace SELA's Action Committee on marine products whose mandate expires this year. Mexican Director General of International Fisheries Alonso Lopez Cruz was elected chairman of the Committee for its final year, replacing Ecuador's fisheries Subsecretary Tully Loor.

The significance of this development goes beyond the mere substitution of one organization for another. The SELA Action Committee on Marine Products was never intended to be a permanent institution. The Committee's temporary nature made it difficult to formulate strategy and especially to obtain funding from participating nations. The participants seemed confident that the creation of a permanent regional fisheries organization was a significant and necessary step toward obtaining governmental funding and demonstrating participants' commitment to a regional approach to fishery problems. Beyond that, the meeting seemed to have been largely educational. The participants analyzed technical matters and largely avoided both politics and any significant move toward regional licensing. (Source: U.S. Consulate General, IFR-81/158.)

Norwegian Fish Canners Merge

A total of 12 companies and exporters of canned fish in Norway have joined forces in the establishment of a new company, Norway Foods Ltd., thus pooling their resources on the export market. This means that a new and more efficient exporter will now compete with foreign companies on the export market, according to the Norwegian Information Service.

The shares capital of Norway Foods Ltd. is $5 million, while assets and machinery are valued at nearly $31 million. Annual turnover is about $75 million, and there are 1,700 employees. About 90 percent of production is meant for export. Production covers a wide range of foodstuffs from the sea (which are not sold as fresh goods) as well as a number of other products.

The head office and marketing division are situated in Stavanger, while the plants will be operated from Bergen. The head of the new concern, Kjell Landaas, says that the aim of the amalgamation is to exploit available resources in a more rational manner, while eliminating at the same time the competition between the previously separate companies. Norway Foods Ltd. also plans to develop new products.

New Mexican Research Vessels

Mexico's National University in Mexico City commissioned its first oceanographic research vessel in December 1980. The $8 million RV *El Puma* is 50 m long, 10 m wide, and displaces 1,000 t. The vessel was built in Norway, and according to Mexican officials is equipped with six laboratories and equipment for multidisciplinary research which will include fisheries research. The *El Puma* is the newest addition to Mexico's rapidly expanding marine research program.

The vessel was designed for research and training in physical, chemical, geophysical, geological, and biological oceanography. It is crewed by 14 and has ample room for 20 scientists. The vessel can stay at sea almost a month before returning to port, and reportedly will cost $2 million a year to operate. Meanwhile, a sister ship to *El Puma* is being constructed at the same shipyard and is expected to operate in the Gulf of Mexico sometime this year. (Source: IFR-81/180.)

Flounders, Oyster Seed, and a Big, Expensive Tuna

. . . . **The arrowtooth flounder, *Atheresthes stomias*, showed a marked increase** in landings on the Oregon coast last year, according to the Department of Fisheries and Wildlife. Landings for 1981 were approximately 1,310,000 pounds, compared with an average of 521,000 pounds landed for the previous 3 years. The price paid to the fishermen ran $0.09-0.10/pound. Surveys have shown that the arrowtooth flounder is sparce along the southern coast of Oregon but that there seems to be an abundance from north of Newport up the coast and into Alaska. Large amounts have been found around the Columbia River area. The species is filleted and utilized for food. The developing market for the species reportedly accounts for the increase in landings. . . .

. . . . The Shinnecock Tribal shellfish mariculture operation in Southhampton, N.Y. has incorporated **passive and active solar and waste heat recovery energy-savings techniques** to heat incoming saltwater, according to a New York Sea Grant report. By using these methods, significant energy savings can be realized by reducing the amount of fuel oil normally needed for water heating purposes. The system is designed to produce an estimated 50 million shellfish seed which will grow to market size in the field operation. Although their primary species will be oysters, they also plan to diversify into production of hard clams and scallops and to provide seed to other mariculture efforts . . . .

. . . .Aristotle, who must have never tried sashimi, called large, old tuna (probably giant bluefins) "unfit even for pickling." **But a record ¥1,500,000 was paid for a 160 kg bluefin tuna** (round weight) in Japan in early January, according to James Ianelli, staff member of the Inter-American Tropical Tuna Commission. At an exchange rate of US$1.00 = ¥220.00, that would mean a price per kilogram of $42.61, per pound of $19.37, and per short ton of $38,740. In 1979, author Roger Revelle cited a price of $26,000 per ton as being "high" for the large bluefins. . . .

. . . .Virginia Institute of Marine Science (VIMS) **parasitologists are tracking a microscopic parasite,** ***Trypanoplasma bullocki,*** that killed many very young summer flounders in Chesapeake Bay last winter, and gauging its effect on flounders available for later harvest. Virginia landings of summer flounder dropped from 10 million pounds in 1979 to only 4.3 million pounds in 1981. "We do not know how extensive its historical damage has been," said Eugene Burreson, a VIMS fish pathologist. "Since our first dependable data is associated with the 1980 year class, we plan to follow the recruitment of this year class into harvestable stocks in hopes that some of these answers will be yielded," he said. Commercially, flounders are the most important food finfish landed in Virginia, recently ranking in value ahead of second-place gray trout or weakfish by a 3 to 1 margin. . . .

. . . .From 1 January to 22 December 1981, **the U.S. Coast Guard conducted boardings of fishing vessels in the Atlantic area** north of Cape Fear and in the Gulf of Maine to enforce Federal fisheries laws. In this 356-day period, Spanish vessels received 19 written warnings and 73 violations, Italian vessels received 5 written warnings and 4 violations, and Japanese vessels received 3 violations, according to the U.S. Coast Guard. A violation can result in a civil penalty of up to $25,000 for each offense. . . .

. . . .**One of the most stringent marine conservation laws in Texas' history** was passed during 1981, according to the Texas Parks and Wildlife Department. This was House Bill 1000 banning the sale of red drum (redfish) and spotted seatrout (speckled trout) taken from Texas waters. Meanwhile, the minimum length limit was increased from 14 to 16 inches, and no redfish longer than 30 inches may be retained by fishermen. The law, which went into effect 1 September, was supported by the Parks and Wildlife Commission to allow a dwindling resource to make a comeback. The ban on sales of trout and redfish may be reviewed by the Commission after 2 years. . . .

. . . .**Alaskan fishermen reported harvesting 40 tons of food and bait herring** in Yakutat Bay last fall. There is no history of winter herring fisheries in Yakutat Bay with the exception of some small harvests in the early 1970's, and the increased activity was probably prompted by a 3-month delay in the opening date for the winter herring fishery in Southeast Alaska, according to the Alaska Department of Fish and Game. As yet, little information is available about the Yakutat fishery's potential, so future fishing will be closely monitored. A conservative management approach is anticipated to protect existing stocks until more is known about them. . . .

. . . .The University of Alaska Sea Grant College has announced the **establishment of the Lowell Wakefield Fisheries Symposia series,** named after the late Alaska king crab pioneer. The symposia, one or two per year, will provide a forum for fisheries scientists, fisheries managers, and industry to review the current status of knowledge about particular Alaskan fisheries and to allow for the development of long-range programs to provide information to assist the State and Federal Governments in developing appropriate management programs. The first, on the snow crab, was held in early May in Anchorage. . . .

Editorial Guidelines for *Marine Fisheries Review*

Marine Fisheries Review publishes review articles, original research reports, significant progress reports, technical notes, and news articles on fisheries science, engineering, and economics, commercial and recreational fisheries, marine mammal studies, aquaculture, and U.S. and foreign fisheries developments. Emphasis, however, is on in-depth review articles and practical or applied aspects of marine fisheries rather than pure research.

Preferred paper length ranges from 4 to 12 printed pages (about 10-40 manuscript pages), although shorter and longer papers are sometimes accepted. Papers are normally printed within 4-6 months of acceptance. Publication is hastened when manuscripts conform to the following recommended guidelines.

The Manuscript

Submission of a manuscript to *Marine Fisheries Review* implies that the manuscript is the author's own work, has not been submitted for publication elsewhere, and is ready for publication as submitted. Commerce Department personnel should submit papers under completed NOAA Form 25-700.

Manuscripts must be typed (double-spaced) on high-quality white bond paper and submitted with two duplicate (but not carbon) copies. The complete manuscript normally includes a title page, a short abstract (if needed), text, literature citations, tables, figure legends, footnotes, and the figures. The title page should carry the title and the name, department, institution or other affiliation, and complete address (plus current address if different) of the author(s). Manuscript pages should be numbered and have 1½-inch margins on all sides. Running heads are not used. An "Acknowledgments" section, if needed, may be placed at the end of the text. Use of appendices is discouraged.

Abstract and Headings

Keep titles, heading, subheadings, and the abstract short and clear. Abstracts should be short (one-half page or less) and double-spaced. Paper titles should be no longer than 60 characters; a four- to five-word (40 to 45 characters) title is ideal. Use heads sparingly, if at all. Heads should contain only 2-5 words; do not stack heads of different sizes.

Style

In style, *Marine Fisheries Review* follows the "U.S. Government Printing Office Style Manual." Fish names follow the American Fisheries Society's Special Publication No. 12, "A List of Common and Scientific Names of Fishes from the United States and Canada," fourth edition, 1980. The "Merriam-Webster Third New International Dictionary" is used as the authority for correct spelling and word division. Only journal titles and scientific names (genera and species) should be italicized (underscored). Dates should be written as 3 November 1976. In text, literature is cited as Lynn and Reid (1968) or as (Lynn and Reid, 1968). Common abbreviations and symbols such as mm, m, g, ml, mg, and °C (without periods) may be used with numerals. Measurements are preferred in metric units; other equivalent units (i.e., fathoms, °F) may also be listed in parentheses.

Tables and Footnotes

Tables and footnotes should be typed separately and double-spaced. Tables should be numbered and referenced in text. Table headings and format should be consistent; do not use vertical rules.

Literature Citations

Title the list of references "Literature Cited" and include only published works or those actually in press. Citations must contain the complete title of the work, inclusive pagination, full journal title, the year and month and volume and issue numbers of the publication. Unpublished reports or manuscripts and personal communications must be footnoted. Include the title, author, pagination of the manuscript or report, and the address where it is on file. For personal communications, list the name, affiliation, and address of the communicator.

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Authors must double-check all literature cited; they alone are responsible for its accuracy.

Figures

All figures should be clearly identified with the author's name and figure number, if used. Figure legends should be brief and a copy may be taped to the back of the figure. Figures may or may not be numbered. Do not write on the back of photographs. Photographs should be black and white, 8- × 10-inches, sharply focused glossies of strong contrast. Potential cover photos are welcome but their return cannot be guaranteed. Magnification listed for photomicrographs must match the figure submitted (a scale bar may be preferred).

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Finally

First-rate, professional papers are neat, accurate, and complete. Authors should proofread the manuscript for typographical errors and double-check its contents and appearance before submission. Mail the manuscript flat, first-class mail, to: Editor, *Marine Fisheries Review*, Scientific Publications Office, National Marine Fisheries Service, NOAA, 7600 Sand Point Way N.E., Bin C15700, Seattle, WA 98115.

The senior author will receive 50 reprints (no cover) of his paper free of charge and 100 free copies are supplied to his organization. Cost estimates for additional reprints can be supplied upon request.

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